APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

REVS. 1112-1648 VOL. 12, NO. 3 MARCH 1959

IN TWO SECTIONS • SECTION 1

GENERAL

MECHANICS OF SOLIDS

MECHANICS OF FLUIDS

HEAT

COMBINED FIELDS AND MISCELLANEOUS

Published Monthly by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS at Easton, Pa., and edited by Southwest Research Institute with the co-operation of Linda Hall Library.

APPLIED MECHANICS Reviews

Under the Sponsorship of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS • THE ENGINEERING FOUNDATION • SOUTHWEST RESEARCH INSTITUTE
OFFICE OF NAVAL RESEARCH • AIR FORCE OFFICE OF SCIENTIFIC RESEARCH, (ARDC) • NATIONAL SCIENCE FOUNDATION

Industrial Subscribers

AMERICAN MACHINE AND FOUNDRY COMPANY • THE BABCOCK & WILCOX COMPANY • BORG-WARNER CORPORATION • CATERPILLAR TRACTOR COMPANY • FORD MOTOR COMPANY • GENERAL DYNAMICS CORPORATION • GENERAL MOTORS CORPORATION • M. W. KELLOGG COMPANY SHELL DEVELOPMENT COMPANY • STANDARD OIL FOUNDATION, INC. • UNION CARBIDE CORPORATION • UNITED AIRCRAFT CORPORATION UNITED SHOE MACHINERY CORPORATION • WESTINGHOUSE ELECTRIC CORPORATION • WOODWARD GOVERNOR COMPANY

EDITOR	Martin Goland
EDITORIAL ADVISORS	H. L. Dryden T. von Karman S. Timoshenko
EXECUTIVE EDITOR	Stephen Juhasz
ASSOCIATE EDITORS	H. Norman Abramson, P. M. Ku, E. Carafoli, J. C. Shipman, G. Herrmann, K. Washizu
ASSISTANT EDITORS	S. Gardiner, S. Lechtman, L. Nevin, L. Graf, L. McGrath, D. Wick
PUBLICATIONS BUSINESS MANAGER	S. A. Tucker
OFFICERS OF ASME	G. B. Warren, *President* E. J. Kates, *Treasurer* O. B. Schier, II, *Secretary*

Editorial Office: **APPLIED MECHANICS REVIEWS, Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas, U. S. A.**

Subscription and Production Office: **The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., U. S. A.**

HOW TO OBTAIN COPIES OF ARTICLES INDEXED: See section after Books Received for Review.

APPLIED MECHANICS REVIEWS, March 1959, Vol. 12, No. 3. Published Monthly by The American Society of Mechanical Engineers at 20th and Northampton Streets, Easton, Pa., U. S. A. The editorial office is located at the Southwest Research Institute, San Antonio 6, Texas, U. S. A. Headquarters of ASME, 29 West 39th St., New York 18, N. Y., U. S. A. Price $2.50 per copy, $25.00 a year. Changes of address must be received at Society headquarters seven weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-laws: The Society shall not be responsible for statements or opinions advanced in papers or printed in its publications (B13, Par. 4). . . . Entered as second-class matter, January 11, 1948, at the Post Office at Easton, Pa., under the Act of March 3, 1897. ©Copyrighted, 1959, by The American Society of Mechanical Engineers.

APPLIED MECHANICS REVIEWS

VOL. 12, NO. 3 MARTIN GOLAND *Editor* MARCH 1959

HYDRODYNAMIC LUBRICATION AND ITS IMPLICATION FOR JOURNAL BEARING DESIGN

F. T. BARWELL

ELECTRIC TRACTION ENGINEER (RESEARCH), BRITISH TRANSPORT COMMISSION, LONDON, (FORMERLY HEAD OF LUBRICATION AND WEAR DIVISION, MECHANICAL ENGINEERING RESEARCH LABORATORY, GLASGOW).

INTRODUCTION

The theory of hydrodynamic lubrication first formulated by Reynolds in 1886 (65) continues to excite the interest of both theoreticians and experimentalists. There are two reasons for this continued interest. One arises from the complexity of the theoretical problems associated with operation of an actual bearing and the second from mechanical engineering developments, particularly the requirement for operation at high linear speeds which has led to a demand for greater precision in design. Reynolds' work had been preceded by the experimental discovery of hydrodynamic lubrication by Beauchamp Tower in 1885 (85) and further confirmation was soon available as represented by the work of Michell (50). However, experimental investigation of the subject has been hampered by the inevitably imperfect nature of the components used in the tests. Departures from circularity, variations in surface finish, distortion of the bearing due to thermal expansion or elastic deformation and the variation of viscosity of the lubricant with temperature as it passes through the bearing, limit the reproducibility of experiments and the accuracy of generalizations based thereon.

BOUNDARY CONDITIONS

Although representing a major advance, Sommerfeld's work (70) had somewhat unfortunate results. He assumed a bearing to be of infinite breadth and that the fluid was able to withstand negative pressures equally as well as positive pressures. The latter assumption presupposed a continuum surrounding the shaft completely, which cannot be relied upon to occur in practice. This lead to the prediction that, in the case of a bearing which surrounded the shaft completely, the locus of the shaft center would comprise a straight line situated at 90° to the line of application of the load. Experimental measurements on the behavior of real bearings failed to support this prediction and the locus actually observed could generally be most simply described as a semi-circle joining the center of the bearing with the point of intersection of the line of loading with a circle drawn to represent the radial clearance. This led, for a time, to an unfortunate estrangement between the theoretical and the experimental investigators in this field. However, it has recently been shown experimentally by Floberg (26) that, if a bearing was so provided with seals at its edges as to restrict all movement of lubricant in an axial direction and if the external mean pressure was raised sufficiently above atmospheric, the locus predicted by Sommerfeld was obtained.

The main obstacle to the application of Reynolds' theory to practical design, and one of the major drawbacks of Sommerfeld's approach, has been the difficulty of solving the equations in a three-dimensional form. An early solution of the problem by Kingsbury (45) was to employ the electrolytic tank analogy and indeed design procedures were worked out wherein relationships were derived from two-dimensional solutions and then modified by factors derived from the electrolytic tank analogy (81), (5). Numerical methods of solution have been used many times (66), (40), (9) and, with the advent of modern electric computers, the complete range of equations has been worked out and published by a number of workers (77), (59), (57), (62). However, there remain many problems arising from the initial assumptions. In the first instance, the integration of the pressure curve to derive load-carrying capacity must be carried out between the appropriate limits—Reynolds suggested that these were defined by $P = 0$ at the inlet and that $P = 0$ and $\dfrac{dp}{dx} = 0$ governed the outlet conditions. There is an indication from experimental work that the position where pressure begins to increase may well be determined by the quantity of oil supplied to the bearing (91), (29). Moreover, there is evidence (22), (41) that negative pressures exist. These pressures are themselves of necessity of small magnitude compared with the positive pressures in a well-loaded bearing but their existence throws doubt on the $\dfrac{dp}{dx} = 0$ limit. Sedney et al (67) have suggested that $P = K \dfrac{dp}{dx}$ at the outlet. Cole and Hughes (16) constructed a bearing of glass and observed the actual position taken up by the film by causing it to fluoresce under the action of ultraviolet light. They showed that the point at which a continuous film disintegrated into fibrils was considerably later than that usually assumed in theoretical treatments. This does not of course provide direct evidence of the extent of the pressurised region of the film but does throw further doubt on the validity of the $\dfrac{dp}{dx} = 0$ criterion.

Similarly, in theoretical friction studies it is usually assumed that the film is continuous. This results in an overestimation of the magnitude of frictional loss.

LIMITATIONS OF REYNOLDS' THEORY

Other assumptions made by Reynolds may not be justified under extreme circumstances as follows

1. that viscosity may be assumed to be constant throughout the pressure area;
2. that the inertia terms may be neglected;
3. that the fluid is incompressible;
4. that the fluid is Newtonian;
5. that any motion of the fluid in a direction normal to the surfaces will be restricted as compared with its motion parallel thereto, and that there will be no transverse pressure gradient.

Evidence exists that neglect of the inertia terms, while it may be important in extreme cases, is unlikely to affect design procedures of bearings for normal use (57), (82), (70), (6), (25), (89), (42). As with inertia terms, the variation of viscosity with pressure is unlikely to be important in normally loaded bearings, although it has undoubted significance in situations such as gear flanks and ball bearings where intense loads are carried between hardened surfaces (78), (52), (44), (47), (35).

The main difficulty arises, however, from variation of viscosity with temperature. It is clear that, in any bearing, the temperature of the lubricant will be increased as it is sheared and this, by consequent alteration in viscosity, will affect the pressure distribution, friction and load carried. In the case of unloaded or concentric bearings, Hagg (31) made an analysis to allow for the variation in viscosity and consequent velocity across the film. A particularly important conclusion was that, as speed was raised, the friction torque did not increase proportionately as would be expected from iso-viscous theory but, in certain favorable circumstances, may reach a maximum and may even fall off as speed is further increased. This was strikingly confirmed experimentally by Muskat and Morgan (51).

Variation of velocity across the profile must also result in the generation of pressure. Cameron (10) and Zienkiewicz (93) have elucidated this. However, this factor is not particularly important for design.

THERMAL CONSIDERATIONS

The extension of Hagg's work to loaded bearings operating at considerable eccentricity is rendered difficult by variations in film thickness and therefore in rate of shear around the periphery (60), and the experimental observations available in the literature cannot be co-related in any simple manner (48), (15). If the assumption is made that, in a running bearing, the majority of the heat is transferred by forced convection in the lubricant rather than by conduction through the bearing housing, it is possible to calculate by numerical methods the distribution of pressure, frictional drag, etc., within the bearing. This was first done by Christopherson (14). He showed that the results obtained for load-carrying capacity were equivalent to those obtained with a hypothetical lubricant having a constant viscosity equal to that of the oil in question at a temperature selected on the assumption that the temperature rise of the oil leaving the sides of the bearing averaged one half of the total rise. The solution with the viscosity averaged on this basis gave an almost identical value for load-carrying capacity and temperature rise as that derived when the viscosity of the oil was treated as a variable. Friction torque was some 14% high when viscosity was averaged. The energy equation has also been studied by Charnes, Osterle and Saibel (12). Unfortunately, it has been recently shown experimentally (16) that the adiabatic assumption by no means represents the facts and that a considerable portion of the heat generated is conducted away through the shaft and housing. Moreover, the maximum temperature occurs at or near the point of minimum film thickness. Most theoretical treatments have assumed that, owing to the lubricant still being in a state of intense shear in the diverging portion of the bearing, the temperature would continue to rise. It has also been pointed out (13) that even though in many machines the shaft itself is not situated in a position where it can readily dispose of its heat, it may act as a regenerator in so far as it receives heat when passing through the pressure film which it gives up in passing through the unpressurised region. This leads to a greater uniformity of temperature throughout the oil film than would have been predicted from the adiabatic theory. Wilcock (92) suggests that, for design purposes, it is wise to regard the bearing as a "mixer" in which oil is fed in at one temperature and may be considered as being withdrawn at the mixer temperature.

DESIGN PROCEDURES

Even if, for design purposes, we neglect the amount of heat dissipated by conduction and assume an average viscosity for the oil film, there still remains the difficulty of predicting what this viscosity will be. The designer has now at his disposal a wealth of experimental data which, by reason of the wide differences in experimental conditions, is not easily condensed into a generalized form. There also exist a number of tables or curves which have been calculated from theory. These, however, take the form of rather complex functions which are not easily manipulated to form a generalized treatment. A useful approximation (55) has been developed by Ocvirk to a stage which provides useful algebraic expression which can be manipulated in the course of a search for the best design for a given set of circumstances. Taking Reynolds' equation and neglecting terms covering the departure from linear variation of velocity in the longitudinal direction, an approximation is obtained, the validity of which diminishes as the width of the bearing increases. The modern tendency is to use narrow bearings and the approximation is quite close for breadth-diameter ratios of one half and moderately accurate for breadth-diameter ratios of unity. The following expression relating load-carrying capacity with speed, viscosity and the dimensions of the bearing results

$$\frac{P}{\eta V}\left(\frac{c}{r}\right)^2\left(\frac{d}{b}\right)^2 = \frac{\varepsilon\pi}{(1-\varepsilon^2)^2} \times \sqrt{1 + 0.621\ \varepsilon^2}$$

where

P = load per inch breadth
η = viscosity
V = peripheral velocity of shaft
c = radial clearance
r = radius of shaft
d = diameter of shaft
b = breadth of shaft
ε = eccentricity ratio

Mention of breadth-diameter ratio introduces one of the major anomalies of this subject. On the basis of iso-viscous theory, the optimum breadth-diameter ratio is usually calculated (81), (41) to be unity or over. However, modern practice, particularly with high-speed bearings, indicates that a shorter bearing is desirable (4), (27), (86). It is likely that the reason for the practicability of the shorter bearing arises from factors which are not taken into account in the simple theory, such as deflection of the shaft and thermal aspects.

In solving the cardinal problem of bearing design, the determination of effective viscosity of operation, it has generally been the practice to neglect the heat conducted away through the bearing shell and to draw up some form of heat balance (37), (46), (75), (74), (36) between the heat dissipated in friction and the amount carried away by a lubricant. A difficulty here is the prediction of oil flow. Most workers (49), (90), (16) have divided this flow into two components, one arising

from the hydrodynamic action of the bearing itself and the other being governed by the pressure used to force oil into the bearing. It has not however been demonstrated that these two aspects are unconnected. In particular, as indicated earlier, it is possible that the extent of the oil film and indeed the volume of oil subject to hydrodynamic action may well be determined to a greater or lesser extent by the pressure of supply at least up to the value giving a complete film at the point of maximum film thickness. Over the range which they investigated, Du Bois and Ocvirk (24) were able to provide an expression for oil flow based on a parameter which included the feed pressure in the denominator. Oil flow varied with feed pressure, sometimes giving higher and sometimes lower rates of flow than that predicted by their approximate theory. It is reasonable to assume that the excess amounts were due to the action of the supply pressure in forcing oil outwards at the sides of the bearing in the unloaded region and that the deficiencies were due to the supply pressure being insufficient to fill a bearing and to give a complete film at the point of convergence, which was one of the basic assumptions of their theory. Selecting from this curve the value of the parameter which corresponds with the theoretical oil flow, it is possible to derive a simple expression connecting the pressure required to give the theoretical flow with other design data. Thus supply pressure becomes a factor to be determined as part of the design procedure and, this having been done, the remainder of the procedure may be based on the premise that flow rate will accord with theory. It must be noted that the results obtained by Cole and Hughes over a wider range are not interpretable in the simple manner demonstrated by Du Bois and Ocvirk. Some study has been made of "starved" bearings (29), (91).

Having obtained expressions for oil flow and friction, it is possible to show that an equilibrium temperature exists, the magnitude of which depends on the appropriate design parameters. Oil flow increases with eccentricity to a greater extent than friction force which leads to rapid re-establishment of equilibrium after a disturbance in conditions. Consider a bearing operating under a certain load and at a certain eccentricity in circumstances when the oil supply is insufficient to carry away the heat generated by friction. This will have two effects, the reduction in viscosity will lead to an increase in eccentricity and will also result in a reduction in friction. The increase in eccentricity will result in the increase in oil flow so that a new equilibrium will be reached rapidly.

If the friction of the bearing is estimated by a slight further approximation of Ocvirk's equation suggested by Barwell (3), the minimum value of clearance required to enable a bearing to operate in any one set of conditions may be determined. This minimum occurs at a definite value of eccentricity and from this it is possible to derive an expression which determines the minimum breadth of the bearing required to carry the load.

PERIODIC LOADING

The foregoing remarks relate to bearings which are subject to a constant load in a fixed direction. When the load rotates, it can be shown that the equivalent steady load is represented by the expression

$$P_1\left(1-2\frac{\omega_l}{\omega}\right)$$

where P_1 = magnitude of rotating load
ω_l = speed of angular rotation of load
and ω speed of shaft

It has been demonstrated by the visual method (16) that the oil film is similar in behavior to that arising from steady load but that it rotates in conformity with rotation of the load. It is thus apparent that a critical condition exists when the velocity of the applied load is equal to half the operational speed. Under these circumstances, theory predicts a zero load-carrying capacity and experiment confirms that operation under these conditions leads to a dangerously high eccentricity (20). When load varies in magnitude but remains constant in direction, that is reciprocating load, similar laws apply and indeed Shawki (68), (69) has shown how vectorial analysis may be applied to bearings. His analysis is capable of further development insofar as he assumes the existence of a continuous film, whereas in practice the film will rupture. Instances of imperfect behavior of bearings may be attributable to the load vector moving at half shaft speed for only a comparatively short period of the load cycle. Studies of bearings under dynamic loads have been made by several workers (38), (71), (79), (8) and under steady load with oscillating motion (2). The degree of flexibility of the bearings may have a significant effect on their response to rotating loads (88).

BEARING WHIRL

One of the most troublesome problems is bearing vibration or "whirl." Clearly from the above remarks, a bearing has little capacity to resist the application of loads at half shaft speed and indeed one would expect any instability of operating to be associated with that frequency (39), (33), (56), (58), (63). Whirl at half shaft speed is an inherent characteristic of a complete bearing and may be overcome as a rule by introducing some discontinuity in the film path. If eccentricity due to steady loading exceeds a comparatively low value, whirl of the kind disappears. Moreover, evidence exists that whirl only occurs when the lubricant film is unbroken. When rupture occurs, stable operation is rapidly achieved. Another type of whirl exists which has been shown (54), (39), (53), (58) to be associated with the dynamic properties of the shaft and possibly of the bearing supports. There is a strong tendency for this type of bearing instability to occur when the speed of rotation exceeds twice the natural frequency of the shaft in transverse vibration. This form of whirl may be best overcome by ensuring that the steady load applied to the bearing is sufficient to cause it to operate at high eccentricity.

HYDROSTATIC LUBRICATION

The feasibility of lubricating a bearing hydrodynamically in any given set of circumstances is determined by the possibility of selecting the design parameters breadth, clearance and viscosity in association with speed and load so as to provide a film thickness of adequate magnitude. In certain cases, either of high load or low speed, it becomes impossible to do this, but it is still possible to obtain the main benefits of fluid film lubrication by arranging to supply fluid to the loaded side of the bearing at a pressure sufficient to balance the applied load. Such hydrostatic bearings have been thoroughly treated by Fuller (28). It is not necessary for the fluid to be a liquid and very effective bearings have been used which employ air or steam as the pressure medium (30).

AIR BEARINGS

The increasing tendency toward higher speeds for rotating machinery renders it possible for air and other gases to be used as lubricants in the conventional hydrodynamic manner. Installation of air bearings may be a matter of great simplicity because they will aspirate air from the surroundings without any auxiliary feeding equipment whatsoever. Subject to consideration of compressibility (19), (83), (84), (1), (43), (23), the normal laws of hydrodynamics apply and it has been estimated (18) that a load corresponding to 1 lb/sq. in. per 1,000 rpm is a useful criterion for determining whether or not an air bearing shall be employed.

REFERENCES

1 Ausman, J. S., The fluid dynamic theory of gas-lubricated bearings, ASME-ASLE Lubrication Conf. Atlantic City, Oct. 1956. Pap. 56-Lub-6; AMR 10 (1957), Rev. 1651.

2 Barwell, F. T., Milne, A. A., and Webber, J. J., Some experiments on oscillating bearings, *Trans. Instn. Engrs. Shipb. Scot.* **98**, p. 267, (1954/55); AMR **8** (1955), Rev. 3579.

3 Barwell, F. T., Lubrication of bearings, London, Butterworth Scientific Publications, 1956; AMR **11** (1958), Rev. 2889.

4 Barwell, F. T., Hydrodynamic lubrication and its application to bearing design, *J. Inst. Petrol.* **42**, p. 304, 1956.

5 Boyd, J., and Raimondi, A. A., Applying bearing theory to the analysis and design of journal bearings. I. II, *J. Appl. Mech.* **18**, p. 298, 1951; AMR **5** (1952), Rev. 1257.

6 Brand, R. S., Inertia forces in lubricating films, *J. Appl. Mech.* **22**, p. 363, 1955; AMR **9** (1956), Rev. 610.

7 Burr, A. H., and Dropkin, D., The prediction of journal-bearing temperatures by the application of heat-transfer theory and data, ASME Semiann. Meeting, San Francisco, 1957. Pap. 57-SA-89; AMR **11** (1958), Rev. 289.

8 Burwell, J. T., The calculated performance of dynamically loaded sleeve bearings III, *J. Appl. Mech.* **18**, p. 393, 1951; AMR **5** (1952), Rev. 565.

9 Cameron, A., and Wood, Mrs. W. L., The full journal-bearing, *Proc. Inst. Mech. Engrs.* **161**, p. 59, 1949; AMR **3** (1950), Rev. 2559.

10 Cameron, A., Hydrodynamic lubrication of rotating discs in pure sliding. A new type of oil film formation, *J. Inst. Petrol.* **37**, p. 332, 1951; AMR **5** (1952), Rev. 1259.

11 Cameron, A., Hydrodynamic theory of gear lubrication, *J. Inst. Petrol.* **38**, p. 614, 1952; AMR **6** (1953), Rev. 2105.

12 Charnes, A., Osterle, F., and Saibel, E., On the energy equation for fluid film lubrication, *Proc. Roy. Soc. Lond. (A)* **214**, p. 1116, 1952; AMR **6** (1953), Rev. 1781.

13 Christopherson, D. G., Proc. Instn. Mech. Engrs. 1957 Conference on Lubrication and Wear: A review of hydrodynamic lubrication, (1958), p. 9.

14 Christopherson, D. G., A new mathematical method for the solution of film lubrication problems, *Proc. Inst. Mech. Engrs.* **146**, p. 126.

15 Clayton, D., and Wilkie, M. J., Temperature distribution in the bush of a journal bearing, *Engineering* **166**, p. 49, 1948; AMR **1** (1948), Rev. 1439.

16 Cole, J. A., and Hughes, C. J., Oil flow and film extent in complete journal bearings, *Inst. Mech. Engrs.*; AMR **9** (1956), Rev. 2791.

17 Cole, J. A., An experimental investigation of temperature effects in plain journal bearings, Proc. Instn. Mech. Engrs. 1957 Conference on Lubrication and Wear (1958), p. 111.

18 Cole, J. A., and Kerr, G., Observations on the performance of air lubricated bearings, Proc. Instn. Mech. Engrs. 1957 Conference on Lubrication and Wear (1958), p. 164.

19 Constantinescu, V. N., On the theory of gas bearings (in French) *Acad. Repub. Pop. Rom. Rev. Mecan. Appl.* **1**, p. 141, 1956; AMR **10** (1957), Rev. 1297.

20 Dayton, R. W., and Simons, E. M., Hydrodynamic lubrication of cyclically loaded bearings *NACA TN* 2544, 1951; AMR **5** (1952), Rev. 1591.

21 Diyachkov, A. K., Investigations of heat generation in the case of friction of plain bearings (in Russian), Symposium on Friction and Wear 10, Moscow, Izd-vo Akad. Nauk SSSR, p. 297, 1955; AMR **10** (1957), Rev. 2728.

22 Dowson, D., Investigation of cavitation in lubricating films supporting small loads, Proc. Instn. Mech. Engrs. 1957 Conference on Lubrication and Wear (1958), p. 93.

23 Dresher, H., Journal bearing with air lubrication (in German), *ZVDI* **95**, p. 35, 1953; AMR **7** (1954), Rev. 2719.

24 Du Bois, G. B., and Ocvirk, F. W., Analytical derivation and experimental evaluation of short-bearing approximation for full journal bearings, *NACA Rep.* 1157, 1953; AMR **8** (1955), Rev. 2933.
See also
Du Bois, G. B., and Ocvirk, F. W., and Webe, R. L., Properties of misaligned journal bearings, ASME-ASLE Lubrication Conference Atlantic City, 1956. Pap. 56-Lub-7; AMR **10** (1957), Rev. 1652.

25 Fishman, I. M., On the motion of a very viscous liquid between journal and bearing (in Russian), *Prikl. Mat. Mekh.* **14**, p. 593, 1950; AMR **4** (1951), Rev. 3741.

26 Floberg, L., The infinite journal bearing considering vaporisation, *Trans. Chalmers Univ. Technol.* no. 189, 1957; Göteborg, Gumperts Förlag.

27 Fogg, A., The length-diameter ratio of journal bearings. Proc. Seventh Int. Congr. Appl. Mech. **4**, p. 180 (1948); AMR **4** (1951), Rev. 499.

28 Fuller, D. D., Theory and practice of lubrication for engineers, New York, John Wiley, and Sons, 1956.

29 Fuller, D. D., and Sternlicht, B., Preliminary investigations of minimum oil-feed rates for fluid-film conditions in journal bearings. *Trans. ASME* **78**, p. 1193, 1956; AMR **10** (1957), Rev. 1985.

30 Grinnell, S. K., and Richardson, H. H., Design study of a hydrostatic gas bearing with inherent orifice compensation, ASME Ann. Meet. Chicago, 1955. Pap. 55-A-177; AMR **9** (1956), Rev. 2784.

31 Hagg, A. C., Heat effects in lubricating films, *Trans. ASME* **66** (A) p. 72, 1944.

32 Hagg, A. C., and Warner, P. C., Oil whip of flexible rotors, *Trans. ASME* **75**, p. 1339, 1953; AMR **7** (1954), Rev. 1684.

33 Hagg, A. C., and Sankey, G. O., Some dynamic properties of oil film journal bearings with reference to the unbalance vibration of rotors, ASME. Ann. Meet., Chicago, 1955. Pap. 55-A-45; AMR **9** (1956), Rev. 1665.

34 Harrison, W. J., The hydrodynamical theory of lubrication with special reference to air as a lubricant, *Trans. Camb. Phil. Soc.* **22**, p. 49, 1919.

35 Hartung, H. A., The pressure-viscosity effect background, ASME Ann. Meet., New York, Dec. 1957. Pap. 57-A-277, AMR **11**, (1958), Rev. 2895.

36 Heidebroek, E., and Hagedon, Calculation of the friction heat and the necessary amount of cooling-oil for high speed journal bearings (in German), *Technik* **6**, p. 21, 1951; AMR **5** (1952), Rev. 315.

37 Hersey, M. D., On the laws of lubrication of journal bearings ASME Spring Meeting, 1915.

38 Hersey, M. D., and Snapp, R. B., Testing dynamically loaded bearings. I. A short history of bearing test machines, ASME-ASLE Lub. Conf. Atlantic City, Oct. 1956. Pap. 56-Lub. 3; AMR **10** (1957), Rev. 3138.

39 Hull, E. A., Oil-whip resonance, ASME Ann. Meet., New York, Dec. 1957. Pap. 57-A-169; AMR **11** (1958), Rev. 2896.

40 Jacobson, M. J., Charnes, A., and Saibel, E., Studies in lubrication, X. The complete journal bearing with circumferential oil inlet, First Ann. Conf. ASME-ASLE, Baltimore, 1954. Pap. 54-Lub-10; AMR **8** (1955), Rev. 1233.

41 Jakobson, B., and Floberg, L., The finite journal bearing considering vaporisation, *Trans. Chalmers Univ. Technol.*, no. 190, Göteborg, Gumperts Förlag. 1957.

42 Kaklert, W., The influence of inertia forces in the hydrodynamic theory of film lubrication (in German), *Ing.-Arch.* **16**, p. 371, 1948; AMR **4** (1951), Rev. 1417.

43 Katto, Y., and Soda, N., Theory of lubrication by compressible fluid with special reference to air bearing, Proc. 2nd Japan Nat. Congr. Appl. Mech., 1952; AMR **8** (1955), Rev. 2935.

44 Kochanowsky, W., Influence of pressure on viscosity and its effects on lubrication of sliding surfaces (in German), *Kolloid Z.* **131**, p. 74, 1953; AMR **7** (1954), Rev. 669.

45 Kingsbury, A., On problems on the theory of fluid film lubrication with an experimental method of solution, *Trans. ASME* **53**. Pap. ARM 53-5-11, 1931.

46 Lee, J. C., Analysis of partial journal bearings under steady loads, ASME-ASLE Lubrication Conf., Indianapolis, 1955. Pap. 55-Lub.-1; AMR **9** (1956), Rev. 3461.

47 McEwan, E., The effect of variation in viscosity with pressure on the load-carrying capacity of the oil film between gear teeth, *J. Inst. Petrol* **38**, p. 342, 1952; AMR **6** (1953), Rev. 2106.

48 McKee, S. A., White, H. S., and Swindells, J. F., Measurements of combined frictional and thermal behaviour in journal bearing lubrication, *Trans. ASME* **70**, p. 409, 1948; AMR **1** (1948), Rev. 905.

49 McKee, S. A., Oil flow in plain journal bearings, *Trans. ASME* **74**, p. 841. 1952; AMR **6** (1953). Rev. 690.

50 Michell, A. C. M., The lubrication of plane surfaces. *Z. Math Phys.* **52**, p. 123. 1905.

51 Muskat, M., and Morgan, F., *J. Appl. Phys.* **14**, p. 234, 1943.

52 Needs, S. S., Viscosity-pressure effect on friction and temperature in a journal bearing, ASME Ann. Meet., New York, 1957. Pap. 57-A-66; AMR **11** (1958), Rev. 2894.

53 Newkirk, B. L., and Lewis, J. F., Oil film whirl—An investigation of disturbances due to oil films in journal bearings, *Trans. ASME* **78**, p. 21, 1956.

54 Newkirk, B. L., Varieties of shaft disturbance due to fluid films in journal bearings, *Trans. ASME* **78**, p. 985, 1956; AMR **9** (1956), Rev. 2063.

55 Ocvirk, F. W., Short-bearing approximation for full journal bearings, *NACA TN* 2808, 1952; AMR **6** (1953), Rev. 2384.

56 Orbech, F., Theory of oil whip for vertical rotors supported by plain journal bearings, ASME Ann. Meet., New York, Dec. 1957. Pap. 57-A-171; AMR **11** (1958), Rev. 1842.

57 Osterle, J. F., Chou, Y. T., and Saibel, E. A., The effect of lubricant inertia in journal-bearing lubrication, *J. Appl. Mech.* **24**, p. 494, 1957; AMR **11** (1958), Rev. 1843.

58 Pestel, E., Contribution to the determination of hydrodynamic damping and vibrating properties of journal bearings (in German), *Ing.-Arch.* **22**, p. 147, 1954; AMR **8** (1955), Rev. 890.

59 Philipzik, W., On the hydrodynamic theory of lubrication (in German), *ZAMM* **36**, p. 51, 1956; AMR 9 (1956), Rev. 3458.
60 Pinkus, O., and Sternlicht, B., The maximum temperature profile in journal bearings, ASME Ann. Meet. Chicago, 1955. Pap. 55-A-212; AMR 9 (1956), Rev. 2788.
61 Pinkus, O., Analysis of journal bearings with arbitrary load vector, ASME-ASLE Lub. Conf., Atlantic City, 1956. Pap. 56-LUB-2; AMR 10 (1957), Rev. 2359.
62 Pinkus, O., Solution of Reynolds equation for finite journal bearings, *Trans. ASME* **80**, p. 858, 1958; AMR 11 (1958), Rev. 3846.
63 Poritsky, H., Contribution to the theory of oil whip, ASME Ann. Meet., New York, 1952. Pap. 52-A-64; AMR **6** (1953), Rev. 3281.
64 Purvis, M. B., Meyer, W. E., and Benton, T. C., Temperature distribution in the journal bearing lubricant film, ASME Ann. Meet., Chicago, 1955. Pap. 55-A-216; AMR 9 (1956), Rev. 2789.
65 Reynolds, O., *Trans. Roy. Soc.* **177** (Part I), p. 157, 1886.
66 Sassenfeld, H., and Walther, A., Journal bearing calculation (in German), *VDI - Forschungsheft (B)* **20**, p. 441, 1954; AMR 8 (1955), Rev. 1234.
67 Sedney, R., Charnes, A., and Saibel, E., The Reynolds lubrication equation with smooth outflow, Proc. First U. S. Nat. Congr. Appl. Mech, 1951; AMR 6 (1953), Rev. 3615.
68 Shawki, G. S. A., and Freeman, P., Journal bearing performance under sinusoidally alternating and fluctuating loads, *Proc. Instn. Mech. Engrs.* **169**, p. 689, 1955.
69 Shawki, G. S. A., Journal bearing performance for combinations of steady, fundamental and harmonic components of load, *Proc. Instn. Mech. Engrs.* **171**, p. 795, 1957.
70 Smith, M. I., and Fuller, D. D., Journal bearing operation at superlaminar speeds, *Trans. ASME* **78**, p. 469, 1956; AMR 9 (1956), Rev. 3138.
71 Snapp, R. B., and Hersey, M. D., Testing dynamically loaded bearings, A diesel-engine bearing test machine, ASME-ASLE Lub. Conf., Atlantic City, 1956. Pap. 56-LUB-4; AMR **10** (1957), Rev. 3500.
72 Sommerfeld, A., Zur hydrodynamischen Theorie der Schmiermittelreibung, *Z. Math. Phys.* **50**, p. 97, 1904.
73 Stanton, T. E., On the characteristics of cylindrical journal bearings at high values of eccentricity, *Proc. Roy. Soc. Lond. (A)* **102**, p. 241, 1922.
74 Steller, A., Calculation of journal bearings with liquid lubricant (in German), *Z VDI* **96**, p. 89, 1954; AMR **7** (1954), Rev. 3074.
75 Stephan, H., Temperature and attitude of journal bearings at high speed (in German), *VDI- Forschungsheft (B)* **19**, p. 439, 1953; AMR 7(1954), Rev. 3440.
76 Sternlicht, B., Experimental verification of theoretical investigations into half frequency whirl, ASME-ASLE Lub. Conf., Indianapolis, 1955. Pap. 55-LUB-20; AMR 9 (1956), Rev. 3460.
77 Sternlicht, B., and Maginniss, F. J., Application of digital computers to bearing design, ASME Ann. Meet., New York, 1956. Pap. 56-LUB-5.
78 Sternlicht, B., Influence of pressure and temperature on oil viscosity in thrust bearings, ASME Ann. Meet., New York, Dec. 1957. Pap. 57-A-275; AMR 11 (1958), Rev. 2891.
79 Stone, J. M., and Underwood, A. F., Load carrying capacity of journal bearings, *Soc. Auto. Engrs. Quart. Trans.* **1**, p. 56, 1947; AMR 1 (1948), Rev. 375
80 Swift, H. W., The stability of lubricating films in journal bearings, Min. Proc. Instn. Civil Engrs., **233**, p. 267, 1932.
81 Swift, H. W., Hydrodynamic principles of journal bearing design, *Proc. Instn. Mech. Engrs.* **129**, p. 399, 1935.
82 Too, L. N., A theory of lubrication in short journal bearings with turbulent flow, ASME Ann. Meet., New York 1957. Pap. 57-A-68; AMR 11 (1958), Rev. 2392.
83 Tipei, N., Contributions to the study of hydrodynamic lubrication (in French), *Rev. Mecan. Appl.* **1**, p. 107, 1956; AMR **10** (1957), Rev. 2360.
84 Tipei, N., Hydroaerodynamics of lubrication (in Rumanian), Echitura Academiei Republicii Populare Romine, 1957.
85 Tower, B., *Proc. Instn. Mech. Engrs.* **38**, p. 58, 1885.
86 Vogelpohl, G., On the load-carrying capacity of bearings and its calculation (in German), Forschungsbericht des Wirtschafts und Verkehrsministerium Nordhein-Westfalen, No. 268 (1956); AMR **10** (1957), Rev. 4235; see also *ZAMM* **15**, p. 378, 1935.
87 Wannier, G. H., A contribution to the hydrodynamics of lubrication, *Quart. Appl. Math.* **8**, p. 1, 1950; AMR **4** (1951), Rev. 1416.
88 Watari, A., The motion of rotating shafts supported by flexible bearings, Proc. 1st. Japan Nat. Congr. Appl. Mech., 1951; AMR 8 (1955), Rev. 1929.
89 Wilcock, D. F., Turbulence in high-speed journal bearings, *Trans. ASME* **72**, p. 825, 1950; AMR **4** (1951), Rev. 1864.
90 Wilcock, D. F., and Rosenblatt, N., Oil flow, key factor in sleeve bearing performance, *Trans. ASME* **74**, p. 849, 1952; AMR 5 (1952), Rev. 3062.
91 Wilcock, D. F., Predicting performance of starved bearings, *Lubrication Engng.* **13**, p. 348, 1957; AMR 11 (1958), Rev. 2396.
92 Wilcock, D. F., Predicting sleeve bearing performance, Proc. Instn. Mech. Engrs. 1957 Conference on Lubrication and Wear, 1958, p. 82.
93 Zienkiewicz, O. C., Temperature distribution within lubricating films between parallel bearing surfaces and its effect on the pressure developed, Proc. Instn. Mech. Engrs. 1957 Conference on Lubrication and Wear, 1958, p. 135.

Analytical Methods in Applied Mechanics

(See also Revs. 1120, 1121, 1122, 1123, 1124, 1125, 1133, 1135, 1141, 1203, 1213, 1307, 1309, 1536, 1571, 1573, 1614)

Book—1112. Bronstein, I. N., and Semendjajew, K. A., Handbook of mathematics [Taschenbuch der Mathematik], Leipzig, B. G. Teubner Verlagsgesellschaft, 1958, xii + 548 pp. DM 22.50

This handbook is a translation of the 6th Russian edition which appeared in 1956. It offers to the engineer, physicist and mathematician a review of those parts of elementary and higher mathematics which are of everyday use, stressing in particular the numerical applications.

The first part (pp. 1–95) is devoted to tables of elementary functions and to special functions such as Gamma and Bessel functions, Legendre polynomials, elliptic integrals and probability integral, and to the graphs of elementary functions and a number of important curves which arise in practice.

The second part (pp. 96–168) treats elementary mathematics (arithmetics of approximate values, algebra, plane and solid geometry, plane, spherical and hyperbolic trigonometry).

The third part (pp. 169–225) is concerned with analytic and differential geometry in the plane and in space.

The fourth part (pp. 226–423) is devoted to analysis: Differential and integral calculus; tables of integrals (515 indefinite integrals, the integrands being algebraic, trigonometric and hyperbolic functions, exponentials, logarithms, inverse trigonometric functions, and 45 definite integrals are given); ordinary differential equations; boundary-value problems and partial differential equations of mathematical physics.

The fifth part (pp. 424–506) considers functions of a complex variable, vector calculus (vector algebra and field theory), Fourier series (harmonic analysis) and calculus of variations.

The sixth part (pp. 507–527) gives an introduction to the theory of probability and calculus of observations.

The bibliography (pp. 528–531) contains 95 German and Russian books, the latter in German translations. There is an extensive subject index (pp. 532–548), and 427 figures appear throughout the text. The printing and appearance of the book is very good and up to the standards of the Teubner Publishing House.

In reviewer's opinion, this handbook serves its purpose well, fills a certain gap in the existing English literature, and is not too expensive.

E. Leimanis, Canada

Book—1113. Moulton, F. R., Differential equations, New York, Dover Publications, Inc., 1958, xv + 395 pp. $2. (Paperbound).

1114. Faure, R., Systems of nonlinear differential equations with periodic coefficients. Study of a special case (in French), *C. R. Acad. Sci., Paris* **245**, 19, 1588–1590, Nov. 1957.

1115. Timman, R., Symposium: Eigenvalue problems in mechanics. I. Mathematical fundamentals (in Dutch), *Ingenieur* **70**, 22, 0.65–0.68, May 1958.

A survey is given of the mathematical theory of eigenvalue problems for linear operators. Discussed are the reduction of a differential operator to an integral operator, orthogonality properties, the principle of Rayleigh, the method of Ritz-Galerkin and numeric methods. From author's summary

1116. Van de Vooren, A. I., Symposium: Eigenvalue problems in mechanics. II. Vibration problems (in Dutch), *Ingenieur* **70**, 24, 0.73–0.81, June 1958.

The general theory of vibration problems is developed. This includes the derivation of the Euler equations of motion from Hamilton's principle, the derivation of Rayleigh's principle and its generalization in the form of Ritz-Galerkin equations. A number of applications are considered, namely torsional vibrations of shafts, critical bending vibrations of shafts, stability of control systems, and the aeroplane flutter problem. From author's summary

1117. De Pater, A. D., Symposium: Eigenvalue problems in mechanics. III. Buckling problems (in Dutch), *Ingenieur* **70**, 31, 0.103–0.114, Aug. 1958.

Paper explains the application of the methods described in Professor Timman's paper on problems of elastic stability. The first part treats systems with a finite number of degrees of freedom; the second part deals with continuous elastic systems, viz. bars, plates and cylinders. From author's summary

Book—1118. Mikhlin, S. G., Integral equations, New York, Pergamon Press, Inc., 1957, xii + 338 pp. $12.50.

This volume, the fourth in the series on pure and applied mathematics, is a very good introduction into the theory of integral equations and their applications to certain problems in mechanics, mathematical physics and technology. It is translated from the Russian by A. H. Armstrong.

The general arrangement is as follows: Part I (Methods of solution of integral equations) contains: Equations of Fredholm type (included are those of Volterra type), symmetric equations (theory of Hilbert-Schmidt), singular integral equations (kernels of Cauchy and Hilbert).

Part II (Applications of integral equations) contains: Dirichlet's problem and its application (e.g. torsion of cylinders, problem of flow), the biharmonic equation, application of Green's function (e.g. plane problem in the theory of elasticity, confocal elliptical ring, exterior of two ovals), the generalized method of Schwarz, certain applications of integrals analogous to potentials (e.g. elastic plane with an infinite series of holes, heat potentials), application of the theory of symmetric integral equations (e.g. vibrations of a string and torsional vibrations of a rod), certain applications of the theory of singular integral equations (e.g. two elastic half-planes in contact, pressure of a rigid stamp on an elastic half-plane).

Many completely solved problems add to the usefulness of the text. The book will prove valuable to those readers who wish to have a deeper insight into the theory of integral equations and their applications. J. Lense, Germany

1119. Schwarz, E. R., Design of experiments—blind spot for researchers, *Prod. Engng.* **29**, 39, p. 34, Sept. 1958.

Computing Methods and Computers

(See also Rev. 1578)

Book—1120. Couffignal, L., Numerical solution of systems of linear equations [Resolution numerique des systèmes d'équations linéaires], Vol. II, Paris, Gauthier-Villars, 1956, iii + 180 pp.

This is the second volume of a series of manuals on computing techniques. "Each of these will present, for a particular problem, practical methods of calculation, accompanying tables and diagrams, examples treated in detail, and an adequate theoretical explanation."

Main part of this book is a detailed description of an elimination method for solving a system of linear equations, complete with examples, methods of using a desk calculator and laying out the work. There is some discussion of the difficulties which can arise due to ill-conditioned equations, and of relaxation methods, but the references to recent work are scant, and there is, for example, no mention of compact elimination methods, triangular resolution, Gauss-Seidel iteration, overrelaxation, or many other useful techniques. Author's choice of representing an element by a_{ij}, where i is the column and j the row, is annoyingly different from usual practice. C. C. Gotlieb, Canada

Book—1121. Peltier, J., Numerical solution of algebraic equations [Resolution numerique des équations algebriques], Vol. III, Paris, Gauthier-Villars, 1957, iv + 244 pp.

Book describes at great length the Graeffe method for finding the roots of algebraic equations and the Newton-Raphson iteration for improving them. Layout of the work, checking methods, and the numerical difficulties what can arise (e.g. from close spacing of the roots or from round-off accumulations) are illustrated by means of many detailed examples. Some related topics such as operations on polynomials and the calculation of symmetric functions of the roots are also discussed.

Reviewer's criticism of this book (as well as that reviewed in preceding review) is that author limits himself to discussing only one method of each type. Even for problems with as long a history as this one there does not seem to have evolved a single method, best in all cases, and when one is writing at book length, a discussion of alternatives is mandatory. Thus there should have been some mention, say, of the Bernoulli and Lin iterations.

C. C. Gotlieb, Canada

Book—1122. Crandall, S. H., Engineering analysis—a survey of numerical procedures, New York, McGraw-Hill Book Co. (Engineering Societies Monographs), 1956, x + 417 pp. $9.50.

This is an interesting reference and textbook in the numerical aspects of applied mathematics. Author considers engineering analysis as "(1) construction of a mathematical model for a physical situation and (2) reduction of the mathematical problem to a numerical procedure." The volume is mostly concerned with (2), but author believes that intelligent selection of appropriate numerical schemes requires an understanding of (1). This is an important point and is well taken. Thus in each chapter numerical problems are introduced by considering the genesis of the problem in applied mathematics.

The book is divided into six chapters. Appreciation of the logical sequence is afforded by the author's outline (p. IX):

Lumped-Parameter Systems		Continuous Systems
Chap. 1 ←	Equilibrium Problems	→ Chap. 4
Chap. 2 ←	Eigenvalue Problems	→ Chap. 5
Chap. 3 ←	Propagation Problems	→ Chap. 6

Chapter 1 concerns finite systems of linear algebraic equations. Compact elimination procedures are taken up and considerable attention is given to single-step (Gauss-Seidell) and total-step iterative procedures.

Matrices are introduced in chap. 2. The eigenvalue problem is of the form $Ax = \lambda Bx$ where A and B are symmetric and B is positive definite. Both direct and indirect (iterative) methods are considered with emphasis on the latter. There is also a presentation of the finite iterative schemes of Lanczos, Hestenes, Stiefel and others. Rayleigh and Schwarz quotients are discussed.

Initial-value problems of nonlinear differential equations is the subject of chap. 3. Methods of solution are iteration, Taylor series expansions and finite differences. Truncation errors, round-off errors and stability receive adequate attention.

The remaining chapters take up partial differential equations, and the nature of this material parallels that of the first three chapters as noted in the above outline. Chapter 4 discusses variational problems. Green's functions and integral equations are studied. Finite difference methods are investigated and application is made to both regular and irregular boundaries. Chapter 5 deals with the eigenvalue problem. Propagation problems are the subject of chap. 6. Both implicit and explicit methods are examined.

There are numerous references throughout each chapter. Excellent examples illustrate the ideas and many exercises and problems are available for further enlightenment. Volume is a useful addition to one's library. Y. L. Luke, USA

1123. Krylov, V. I., Convergence of algebraic interpolation with respect to roots of Chebyshev's polynomial for absolutely continuous functions and functions of bounded variation (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **107**, 3, 362–365, Mar. 1956.

1124. Thom, A., and Apelt, C. J., Note on the convergence of numerical solutions of the Navier-Stokes equations, *Aero. Res. Counc. Lond. Rep. Mem.* 3061, 7 pp. + 3 fig., 1958.

Convergence of the numerical solution of the Navier-Stokes equations for steady flow is found to occur if $(qn/\nu)^2 < 20$ in which q is the velocity, $2n$ is the mesh spacing, and ν is the kinematic viscosity. For rapid convergence, the net spacing should be less than one half the value given by the limiting criteria.

M. R. Carstens, USA

Analogies

(See Revs. 1345, 1359, 1493, 1523, 1600, 1608)

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 1115, 1116, 1117, 1134, 1174, 1318, 1571)

Book—1125. Deresiewicz, H., Elements of engineering statics, New York, Columbia Univ. Press, 1958, vi + 124 pp. $3.50.

Vector algebra is used to develop principles of engineering statics. Book is proposed as text for one-semester, first course of engineering students in statics. There are chapters on vector algebra, equilibrium principles, equilibrium of planar systems, equivalence of force systems, simple structures, friction, work-energy methods, and space structures. Virtual work is treated with skill and completeness. The usual graphical concepts and methods are omitted, but perhaps the use of vector notation offsets the solution of certain problems and an understanding of equilibrium principles with graphical techniques. There are 148 problems for student practice, mostly with answers. Although vector algebra is employed, most of the sample problems illustrating the equilibrium of simple structures and mechanisms are necessarily solved by the usual engineering methods of free-body diagrams and equations of equilibrium. L. M. Laushey, USA

Book—1126. Huckert, J., Analytical kinematics of plane motion mechanisms, New York, Macmillan Company, 1958, vii + 209 pp. $7.50.

This undergraduate textbook is based on the educational philosophy that a student learns best "by doing." The emphasis is based on drawing plates rather than on numerical or mathematical problems.

The book covers the usual topics of linkages, cams and gears, with vector and graphical methods stressed. If sufficient drawing time is available the book could be a satisfactory text for a standard course in kinematics. A. H. Church, USA

1127. Krasovskii, N. N., Application of the second method of A. M. Liapunov to equations with time lag (in Russian), *Prikl. Mat. Mekh.* **20**, 3, 315–327, May–June, 1956.

This paper is on a high mathematical level. It concerns the system of differential equations

$$\left.\begin{aligned} \frac{dx_i}{dt} &= X_i\,[x_1(t-b_{i1}(t)),\ldots,x_n(t-b_{in}(t)),t] \\ X_i\,(0,\ldots,0,t) &= 0 \text{ for } t \geqslant 0\ (i=1,\ldots,n) \end{aligned}\right\} \quad [1]$$

and its central problem is the generalization of Liapunov's theorem of asymtotic stability to these equations. The trajectories of the system [1] are considered in a functional space and certain functionals are used instead of Liapunov's functions. Some theorems concerning the stability of the trajectories are proved. There are also several examples showing how the functionals are obtained for special cases of the system [1].

I. Beranek, Czechoslovakia

1128. Glushchenko, I. P., Theorem of the formation of accelerations (in Russian), Sb. Nauch. tr. Leningr. Inzh.-Stroit. In-ta., 22, 71–81, 1955; *Ref. Zh. Mekh.* no. 10, 1956, Rev. 6398.

1129. Garfinkel, B., On the motion of a simple pendulum, *Quart. Appl. Math.* **16**, 2, 192–196 (Notes), July 1958.

Book—1130. Kauderer, H., Nonlinear mechanics [Nichtlineare Mechanik], Berlin, Springer-Verlag, 1958, xi + 684 pp.

The first portion of this large, handsomely printed volume is entitled "Elastostatics" and is devoted to the study of effects of nonlinear relations between stress and strain, with the assumption of small strain being retained. In solving particular problems, such as the torsion of prismatic bars, the flexure of thin plates, and several others in plane strain and plane stress, author employs a stress-strain law which may be written

$$\epsilon_{ij} = (3K)^{-1}\,\sigma_0\delta_{ij} + (2G)^{-1}\,(1+gt_0^{\,2})\,(\sigma_{ij}-\sigma_0\delta_{ij}),$$

where K and G denote, respectively, the bulk and shear moduli, σ_0 the mean stress, Gt_0 the octahedral shearing stress, and g a material constant.

The limitation on the source of nonlinearities seems unfortunate, especially in view of the all-inclusive title of the book; first because it omits the large and significant literature dealing with problems of finite strain, the second because there is serious doubt as to the soundness of the hypothesis according to which there exists a range of infinitesimal strain in which Hooke's law is not valid [cf. C. Truesdell, *J. Rational Mech. Analysis*, **1**, p. 205, 1952, footnote 15].

The second part of this book, entitled "Theory of vibration," occupies 524 of the 680 pages of text. It contains a detailed discussion of the nonlinear vibrations of systems with a single degree of freedom, including motions which are undamped, damped, self-excited, forced, and parametrically excited, as well as some material on such vibrations of systems with two degrees of freedom and of continuous systems, with illustrative examples drawn, for the most part, from mechanical (rather than electrical) problems.

Much worthwhile labor and care have gone into the creation of this book. The reviewer is of the opinion, however, that the unity

of the book would have been enhanced and its vulnerability to criticism much diminished if its contents had been confined to the treatment of nonlinear vibrations of systems of one and two degrees of freedom. H. Deresiewicz, USA

1131. **Kovalevskii, A. S., Experimental problems in mechanics for the first course of the physical and mechanical faculty of the Teaching Institute** (in Russian), Avtoref. Diss. Kand. Ped. Nauk, Leningr. Gos. Ped. In-ta, Leningrad, 1956; *Ref. Zh. Mekh.* no. 4, Rev. 3891.

Instrumentation and Automatic Control

(See also Revs. 1417, 1577, 1579)

1132. **Smirnova, I. M., Stability of approximately ascertained periodic regimes in automatic systems of control** (in Russian), Trudf 2-go Vses. Soveshch. po Teorii Avtomat. Regulirovaniya. Vol. I. Moscow-Leningrad, Izd-vo Akad. Nauk SSSR, 1955, 193–203; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5178.

An examination is made of the stability of the periodic regions of some nonlinear systems of automatic control. In the introduction a description is given (resting on the filter hypothesis) for the approximate determination of periodic regimes of the system

$$D(p)x = K(p)(f(x) + A \sin \omega t) \qquad \left(p = \frac{d}{dt}\right)$$

where $D(p)$ and $K(p)$ are polynomials. This method approaches work done by L. S. Gol'dfarb [*Avtomatika i Telemekhanika* **8**, 5, 349–383, 1947], and M. A. Aizerman [*Inzhen.* **13**, 151–160, 1952]. By means of the method of harmonic balance approximate equations for the disturbed motion are deduced. On the basis of the investigation of these equations approximate conditions for the stability of the forced oscillations are deduced which are comparable with the conditions obtained by L. S. Gol'dfarb (see paper cited above) and by A. I. Lur'e ["Some nonlinear problems of the theory of automatic control," Moscow-Leningrad Gostekhizdat, 1951, 216], indicated for the case of auto-oscillation. It has to be emphasized that the indications given in the paper only determine the stability when the determined suppositions are operating; for instance, for the system, only slightly distinguishable from the linear, deduced on the border of the stability range by a pair of pure imaginary roots. N. N. Krasovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1133. **Popov, E. P., Approximate determination of auto-oscillations and forced oscillations in systems of automatic control** (in Russian), Trudf 2-go Soveshch. po Teorii Avtomat. Regulirovaniya. Vol. 1. Moscow-Leningrad, Izd-vo Akad. Nauk SSSR, 1955, 219–248; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5180.

N. M. Krylov's and N. N. Bogolyubov's method of harmonic balance is described in its application to the investigation of the periodic regimes of some nonlinear systems. In accordance with the character of the nonlinear bonds of the systems being investigated, the systems resolve themselves into three classes. A description is given of the harmonic linearization of the systems of the various classes, and also of the linearization of systems with retardations. The search for the periodic regime (and the explanation of its dependence on the parameters of the system) converges with the solution of equations, which is obtained when the coordinates of some conditional frequency curve, constructed for the linearized system, are equal to zero. Curves are given to show the dependencies corresponding to some of the characteristic cases. Methods of approximate evaluations of stability are described, based on the averaging of the variable coefficients of equations for the disturbed motion or on the investigation of the character of the conditional frequency curve at points corresponding to the possible regimes. General positions are illustrated in a series of concrete schemes. Questions regarding the substantiation of the methods advanced and estimates of their accuracy are not gone into. Undoubtedly many of these methods will give satisfactory results only when determined limitations are in force for the properties of the investigated systems. It is noted that, in the majority of cases, experiment gives good qualitative and quantitative coincidence with the calculations for the methods described. N. N. Krasovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1134. **Ryabov, B. O., The state of natural oscillation in some systems incorporating a nonlinear element with an asymmetrical characteristic** (in Ukrainian), *Avtomatika Akad. Nauk USSR* no. 2, 3–14, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6321.

A method is discussed for determining the conditions for the steady natural oscillation of servo systems in which a nonlinear element with a sawtooth characteristic is asymmetrical both in the "response" region and in the value of its coordinates. The parameters of the steady state of natural oscillation of a servomechanism are determined in which the nonlinear element is of the relay type, with particular constant external forces acting on the system. M. E. Temchenko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1135. **Krinetskii, I. I., Simplified calculation of some nonlinear systems** (in Russian), Trudf Vses. Sovshch. po Teorii Avtomat. Regulizovaniya. Vol. 1. Moscow-Leningrad, Izd-vo Akad. Nauk SSSR, 1955, 299–308; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5206.

A simplified method is proposed for the calculation of the parameters of systems of control containing the nonlinear link (the equation $f(x, x', \ldots, x^n) = -F(x)$, f is the linear, F the nonlinear, function). The equation is linearized by the substitution for the nonlinearity $F(x)$ of the linear function hx (the value of h depends on the amplitude, but in the calculation the maximum possible value for h is adopted). $h = h^*$ is selected so that in the provisory characteristic equation $\Phi(p) + h^* = 0$ there is a pair of pure imaginary roots $\pm i\omega_0$. By substituting $d + i\omega_0$ in the equation $\Phi(p) + Z = 0$ an approximate determination is made of the root of this equation which is closest to the imaginary axis. On the assumption that the character of the transition process is determined by this root, the calculation formulas are then deduced. The proposed method of calculation was checked experimentally and a good measure of agreement was obtained. Questions on the precise theoretical foundations for the method of calculation were not investigated. N. N. Krasovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1136. **Karibskii, V. V., On the question of improving the dynamic characteristics of industrial controllers by means of feedback loops** (in Russian), *Avtomatika i Telemekhanika* **17**, 2, 117–128, Feb. 1956.

It is shown how the behavior of controllers can be improved by addition of integral action (reset) in the feedback loops. Interesting is the difference made between "stiff" and "elastic" feedback. With "elastic" feedback the rate of change of the feedback action is proportional to the output. As an example a Russian pneumatic controller is described. Elastic feedback is obtained

by filling the feedback bellows with a liquid which has to flow through a restriction to enable the bellows to move ("isodromic" time-constant). Theoretical and experimental data are presented. Stability problems are not mentioned, and the treatment of the problem seems incomplete. Interesting are drawing and picture of controller as used for temperature control with chemical (oil) and metallurgical processes. R. G. Boiten, Holland

1137. **Hochrainer, H., Stabilizing elements of feedback control loops** (in German), *Regelungstech.* **5**, 11, 429–434, 1957.

Control systems are studied where there is a stabilizing feedback path in parallel with the controller. Author develops the mathematical theory of such systems for proportional and integral control. Electrical networks for reproducing prescribed transfer functions are described. R. Oldenburger, USA

1138. **Slater, J. M., and Wilcox, D. E., How precise are inertial components?** *Control Engng.* **5**, 7, 86–90, July 1958.

Inertial navigation—a highly specialized form of dead-reckoning—depends upon sensing and integrating changes in vehicle motion to compute velocity, the first time integral of acceleration, and distance, the second. Successful navigation depends strictly on instruments that mechanize the laws of motion with extreme accuracy. A fraction of a dyne-cm of stray torque is usually all that can be tolerated in a gyroscope or accelerometer, and there is a host of potential "claimants" for their share of this torque. The many sources of error are reviewed and means to minimize them are pointed out. From authors' summary

1139. **Kessler, C., Contribution to the theory for a two-step controller** (in German), *Regelungstech.* **10**, 5, 339–342, 1957.

Author analyzes the response of an on-off controller with integral, proportional and derivative feedback, where the on-off controller is treated as the limiting case of a limiter where the slope of the proportional band of the limiter is increased beyond all bounds. Mathematical theory is developed to aid the control designer. R. Oldenburger, USA

1140. **Pamev, I. V., Free oscillation of a gyro bearing linked with a gyro compass, in the case of a ship's navigation** (in Russian), *Trudl Ryazansk. Radiotekhn. In-ta* **1**, 215–221, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5183.

The oscillations of a system are investigated, consisting of two gyroscopes (gyrocompass with a stabilizer) set up on the ship, when the ship is on a settled course (with a constant angular velocity ω). In building up equations in variations, author arrives at a system of equations with periodic coefficients, and then goes over to new variables, in which the obtained system already has constant coefficients. N. N. Moiseev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Tables, Charts, Dictionaries, etc.

(See also Revs. 1392, 1530)

Book—1141. **Onoe, M., Tables of modified quotients of Bessel functions,** New York, Columbia University Press, 1958, 338 pp. $12.50.

Let $A_\nu(z) = zJ_{\nu-1}(z)/J_\nu(z)$ where $J_\nu(z)$ is the Bessel function of the first kind of order ν. $A_\nu(z)$ is called a modified quotient of Bessel functions of the first kind. Similar quotients are defined for Bessel functions of the second and third kinds. Also considered are quotients of the type $zJ_{\nu+1}(z)/J_\nu(z)$. Volume gives tables of $A_\nu(z)$, $z = x$, x: 0(0.01)20, ν = 1(1)16, mostly to 9 significant figures; and $z = ix$, $i = \sqrt{-1}$, x and ν as above, mostly to 10 significant figures. For interpolation, author states that five point Lagrangians yield virtually full accuracy of the tables except near the poles. Spot checks reveal that this is true save that for the $A_\nu(ix)$ tables virtually full accuracy is attained using quadratic interpolation. No auxiliary tables are given to facilitate interpolation near the poles. Here one should exploit the power series expansion near a pole provided in the introduction. Information concerning interpolation in the ν-direction is wanting.

A collection of formulas relating to the functions is given in the introduction. These include contiguous relations, series expansions both convergent and asymptotic, expansions near the zeros and poles of $A_\nu(z)$, continued fraction developments, etc. In equation [2.15] there is a misprint. For $y - 2\nu y$ read $y^2 - 2\nu y$. Preparation of the tables is described. Some references are given to illustrate application of tables. For some tables of quotients of Bessel functions of the second and third kind, see a previous study by the author, "Formulae and tables, the modified quotients of cylinder functions," Report of the Institute of Industrial Science, University of Tokyo, no. 32, 1955. For tables of $1 - (2/z)J_1(z)/J_0(z)$, $z = \alpha i^{3/2}$, α = 0(0.05)10.0, 4 decimals, see Womersley, J. R., "An elastic tube theory of pulse transmission and oscillatory flow in mammalian arteries," *WADC TR* 56–614, January, 1957. Y. L. Luke, USA

Book—1142. **Ferry, A., Measures and units: critical evaluation of the principles of the Giorgi system [Grandeurs et Unites: Expose critique des Principaux Systemes: Systeme Giorgi],** Paris, Gauthier-Villars, 1956, 54 pp.

Elasticity

(See also Revs. 1130, 1159, 1166, 1176, 1184, 1265, 1296, 1302, 1477)

1143. **Pell, W. H., Elastic problem for a ring of uniform force in an infinite body,** *J. Res. Nat. Bur. Stands.* **60**, 4, 365–373, Apr. 1958.

Solution is given to the elastic problem of a force applied normal to and uniformly distributed along a circle in an infinite elastic solid. It is analogous to the Kelvin problem of a force at a point and reduces to it in the special case of a circle of zero radius. The approach is of interest in that it follows to some extent that used by early investigators, including Kelvin, rather than more recent work. G. Pickett, USA

1144. **Kroupa, F., The mixed boundary-value problem of the plane theory of elasticity for an annular region** (in Czech), *Czech. J. Phys.* **6**, 2, 124–139, Apr. 1956.

A general solution of the mixed boundary-value problem of the classical plane theory of elasticity for an annular region is given in the following formulation: on one circle the components of displacement are given, on the other circle the normal and tangential component of stress is given. The Muskhelishvili method of the complex stress function is used. The general solution is carried out in the second section by expanding known functions expressing the boundary conditions in Fourier series, by expanding the wanted complex stress functions $\varphi(z)$ and $\psi(z)$ in Laurent series and logarithmic terms and by determining the coefficients in these series. The convergence of the series for φ and ψ is only proved for the case when the functions expressing the boundary conditions have a continuous third differential coefficient.

From this general solution two special cases are calculated, when the inner circle is stiff and a radial or tangential concentrated force acts on the outer circle. The concentrated force is at the same time newly conceived as the N-th approximation of the

expansion of the Dirac function in a Fourier series. A substitute continuously distributed load is chosen which for larger N corresponds well to reality, the given solution being exact for this substitute load.

Another solution of the same problems is given where it is assumed that the concentrated force acts at one point. This solution is obtained by the superposition of the solution for a half-plane loaded on the boundary by a point force and the solution of the mixed boundary-value problem for an annular region with suitably constructed continuous boundary conditions. By comparing both solutions their equivalence inside the annular region is shown.

Both special cases dealt with, and their possible superposition, are destined for the study of a loaded full tire. The solid inner circle corresponds to the contact of the rubber body with the metal disk, the concentrated force to the contact of the outer circle with the roadway. In transferring the results to this problem it is of course necessary to critically appraise the assumptions used. The approximity of the calculation consists both in the use of the classical linear theory of the elasticity of small deformations and in the assumption that the problem concerned is plane.

From author's summary

1145. Angles d' Auriac, P., General formula for finite elasticity (in French), *C. R. Acad. Sci., Paris* **246,** 13, 1962–1964, Mar. 1958.

Author writes general equations of nonlinear elasticity theory using unconventional notations. His poorly explained Eq. [3] appears to be new. J. L. Ericksen, USA

1146. Angles d' Auriac, P., Equations of finite elasticity of first order (in French), *C. R. Acad. Sci., Paris* **246,** 14, 2101–2103, Apr. 1958.

Author writes linear and particular second-order elasticity equations using unconventional notations.

J. L. Ericksen, USA

1147. Angles d' Auriac, P., A special case of finite elasticity (in French), *C. R. Acad. Sci., Paris* **246,** 15, 2217–2218, Apr. 1958.

Author briefly discusses elastic materials for which strain energy is sum of two parts, one depending only on change of volume, the other only on change of shape.

J. L. Ericksen, USA

1148. Johns, D. J., Approximate formulas for thermal-stress analysis, *J. Aero/Space Sci.* **25,** 8, 524–525 (Readers' Forum), Aug. 1958.

Based on the earlier work of M. A. Biot and N. J. Hoff, the general thermal stress equation for an I-beam heated symmetrically is developed. The maximum and average thermal stress in the flange as well as the maximum stress in the web are mathematically defined. Variables involved are section area, elastic modulus, coefficient of expansion and temperatures at three points. A temperature distribution approach enabling an estimation of the three point temperatures is also presented.

J. P. Vidosic, USA

1149. Penning, P., The generation of dislocations by thermal stresses, *Philips tech. Rev.* **19,** 12, 357–364, 1957/58.

The term dislocation, denoting a particular kind of lattice imperfection in crystalline materials, was first introduced about 20 years ago. Since then dislocations have lost their hypothetical status—their existence is now well-established and they play an essential role in the behavior of crystalline solids.

Dislocations (and other lattice imperfections) have a marked influence on the physical and mechanical properties of solids. This fact is of particular interest in the semiconducting materials germanium and silicon, which are now of considerable technical importance. The present article deals with the formation of dislocations during the cooling of a germanium crystal, the study of which is important both with regard to the problem of how to control the properties of germanium more effectively, and in order to throw fresh light on the origin of dislocations.

From author's summary

1150. Yankovskii, M. I., Problem of thermal stresses in bars of rectangular section (in Russian), Issledovaniya po Vopr. Ustoichivosti i Prochnosti, Kiev, Akad Nauk USSR, 1956, 230–242; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5910.

The distribution of thermal stresses in a rectangular plate when subjected to heating and cooling was examined by means of a polarization optical method. A full description is given of the experimental procedure and of the method used for the calculations of the principle stresses. The results are presented in the form of tables and curves. B. S. Ioffe

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1151. Stoff, K., Temperature stresses in fully welded steel and concrete conduits (in German), *Tech. Mitt. Krupp.* **15,** 8, 263–271, Dec. 1957.

Conduits consisting of concrete with steel walls are analyzed for stresses due to temperature changes. Radial and tangential stresses are found under the assumption of plane stress for conduits having either steel walls inside and out or for the single steel wall case. Numerical examples are worked out.

E. Saibel, USA

Book—1152. Weber, C., and Gunther, W., Torsion theory [Torsions theorie], Braunschweig, Friedr. Vieweg & Sohn, 1958, 306 pp. DM 38.

This is a very good specialized text on the problem of elastic torsion (linear small strain elasticity). The book starts with the general equations of torsion and the usual considerations about stress function and warping function. The next chapter is devoted to the membrane analogy and its applications to thin-walled cross sections and to cross sections with holes. Chapters 3 to 6 discuss the semi-inverse method of Saint Venant, the use of power series, Fourier series, and Green's function. Chapters 7 to 13 deal with the applications of conformal mapping to the torsion problem, and the next three chapters are devoted to the use of inversion in torsion. Chapters 17 to 19 consider stress concentrations, and the last four chapters of the book are devoted to energy methods and to the determination of upper and lower bounds for the torque, stress, and stress function.

The only objection this reviewer raises is that hardly any references are given and that the bibliography is totally inadequate. The book, however, is very readable and has a great wealth of information. Reviewer recommends it highly to research students who are interested in elastic torsion.

A. Phillips, USA

1153. Vocke, W., A closed solution of torsional problem of cylindrical rods; determination of the torsional rigidity (in German), ZAMM **37,** 11/12, 409–415, Nov./Dec. 1957.

For cylindrical shafts under torsion, author studies the effect of a circumferential groove on the distribution of stress as well as on the deformation and the torsional rigidity. The investigation is based on a solution for the torsional stress function in closed form and on some further solutions for flat grooves.

H. Neuber, Germany

1154. Deresiewicz, H., Oblique contact of nonspherical elastic bodies, *J. Appl. Mech.* **24,** 4, 623–624, Dec. 1957.

Author studies the general case of Hertz contact between elastic solids (elliptical area of contact). In previous papers by various

authors [see, e.g., AMR **3** (1950), Rev. 2592; AMR **6** (1953), Rev. 3659; AMR **7** (1954), Rev. 730], additional static and cyclic force systems have been superimposed upon the Hertz normal force and important results obtained. Author here shows how these results can be extended further to the case of general Hertz contact.

J. L. Lubkin, USA

Viscoelasticity

(See also Revs. 1161, 1445)

1155. Gerard, G., Note on mechanical behavior after creep, *J. Aero. Sci.* **25,** 6, 397–398 (Readers' Forum), June 1958.

Effects of prior exposure to creep conditions on subsequent stress-strain properties were investigated for two types of aluminum. One was a commercially pure 3003-0 (reasonable stable metallurgically at the testing temperature of 650 F) and the second was a more complex alloy Alclad 2024-T3 (subject to aging and other metallurgical changes at the testing temperature of 500 F). For the test conditions investigated, prior creep had little effect on subsequent properties of the stable aluminum but might significantly affect the unstable alloy after sufficient exposure time.

B. J. Lazan, USA

1156. Sugiyama, H., Experimental data on the prediction of the creep limit of wood in bending from creep and creep recovery tests, *Res. Rep. Fac. Engng., Meiji Univ.* no. 11, 13–53, Jan. 1958.

Experimental results are given for the behavior of bending creep under constant loading and of the subsequent creep recovery, and for the effect of sustained loading on the stiffness and bending strength of wood. Prediction of the creep limit in bending from these data is made.

Creep tests consisted of the long-time creep tests and of the short-time creep and the subsequent creep recovery tests.

The experiment was conducted (1) under varying room conditions (without conditioning of temperature and humidity) for the purpose of ascertaining and observing practical use from the structural engineering point of view, (2) on small clear specimens, and (3) in the type of pure bending.

From author's summary

1157. Freudenthal, A. M., and Roll, F., Creep and creep-recovery of concrete under high compressive stress, *J. Amer. Concr. Inst.* **29,** 12, 1111–1142, June 1958.

Four series of tests studied creep and creep-recovery of concrete under sustained compressive stresses varying between approximately 15 and 65% of the 28-day compressive strength. Test specimens, loaded at 28 days, were cylinders 10 in. high, 3 and 4 in. in diameter, made with four different mixes. The creep tests were conducted under conditions of controlled temperature and humidity. Shrinkage of unloaded control specimens in the same environment was recorded so that the actual creep curves (total time-dependent deformation minus shrinkage) could be obtained.

Supplementary compression tests were conducted to determine the effect of sustained load on strength and modulus of elasticity of the concrete.

To reproduce and represent the observed creep and creep-recovery curves, a mechanical model was introduced consisting of four elements, each representing a specific type of contribution to total creep. Model constants were evaluated and their variation with respect to mix and applied stress determined.

Using creep equations derived from the model, creep was predicted for four stress levels of each mix of Series IV. The equations were also used for evaluating stress relaxation from various stress levels.

From authors' summary

1158. Berry, D. S., Stress propagation in visco-elastic bodies, *J. Mech. Phys. Solids* **6,** 3, 177–185, May 1958

Paper refers to linear viscoelastic solids. The three-dimensional stress-strain relations are written in a form containing two convolution integrals. The two "relaxation" functions in the integrals reduce to Lamé's constants of the classical relations if time effects are disregarded. A Laplace transform method is applied. Analysis is based on the correspondence between viscoelastic and elastic problems, which has been used for the one-dimensional case and now is extended to the three-dimensional one. Two particular problems are treated: (a) Torsional oscillations in a circular cylinder, as an example of steady-state behavior; (b) spherical stress waves in an infinite solid, due to an impulsive pressure acting on the surface of a spherical cavity inside the solid. The solid is treated as a kind of Maxwell body. Problem exemplifies transient behavior.

B. Gross, Brazil

Plasticity

(See also Revs. 1149, 1169, 1200, 1210, 1223, 1224, 1288)

1159. Hult, J. A. H., and McClintock, F. A., Elastic-plastic stress and strain distributions around sharp notches under repeated shear (in English), 9th Congrès intern. Mécan. appl., Univ. Bruxelles, 1957; **8,** 51–58.

Condensed report presents theoretical investigation of the title problem, which is the limiting case of a very shallow notch in a specimen subjected to torsion. Fatigue cracks are very severe stress raisers and cause plastic flow in some small region, especially in large structures, and the determination of resulting stresses and strains and their distributions around sharp notches by theory of plasticity is difficult. McClintock showed in 1956 that such a solution is possible in the case of longitudinal cracks in cylindrical bars subjected to fully plastic torsion.

In this paper stress and strain distributions are obtained for pure shear with following conclusions: (1) Strain at a sharp zero-angle notch under plastic flow is greater than that for a purely elastic material; (2) strain concentration becomes insensitive to notch angle at high stresses; (3) angle subtended by the region of infinite strain becomes smaller as the notch angle increases; (4) strain amplitude under repeated loading depends on stress range but not on mean stress.

J. J. Polivka, USA

1160. Hu, L. W., and Bratt, J. F., Effect of tensile plastic deformation on yield condition, *J. Appl. Mech.* **25,** 3, p. 411 (Notes), Sept. 1958.

1161. Zhukov, A. M., and Rabotnov, Yu. N., Investigation of plastic deformations in steel in complex loading, *Inzhener. Sbornik, Akad. Nauk SSSR* **18,** 105–112, 1954.

1162. Rovinskii, B. M., and Liutsau, V. G., Relaxation of oriented microstresses, *Soviet Phys.-Tech. Phys.* **2,** 2, 309–313, Feb. 1958. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 2, 345–350, Feb. 1957 by Amer. Inst. Phys., Inc., New York, N. Y.)

Uniaxial tension beyond the elastic limit produces in metal specimens a permanent deformation of the lattice structure which can be eliminated fully only by high-temperature annealing. These stresses can therefore be assumed to be balanced in small volumes and may be classified as microstresses, but must be distinguished from the trivial non-oriented microstresses. By x-ray diffraction methods, authors find that the relaxation of these stresses in copper and aluminum specimens is described by the same equation as that for the relaxation of macrostresses.

A. D. Topping, USA

Rods, Beams and Strings

(See also Revs. 1150, 1151, 1152, 1178, 1179, 1191, 1193, 1219, 1243, 1245, 1280, 1289, 1293)

1163. Padfield, D. G., The motion and tension of an unwinding thread. I, *Proc. Roy. Soc. Lond.* (A) **245,** 1242, 382-407, June 1958.

The fluctuating tensions in a perfectly flexible string unwinding from a stationary package are considered, and the dependence of unwinding tensions on air resistance, unwinding speed, angle of winding on the package, number of "balloons," angle of conical packages, etc., is examined. Unwinding from rotating packages and from the interior of hollow packages is also briefly considered. Predicted and experimented values of the tensions are compared. The stability of different modes of unwinding will be investigated in part II.
From author's summary

1164. Kostitsyn, V. T., Some problems on the friction of flexible bonds (in Russian), *Trudi Seminara po Teorii Mashin i Mekhanizmov In-ta Mashinoved Akad. Nauk SSSR* **16,** 62, 43-55, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5229.

For the case of friction of a flexible thread on the surface of a variable curve the following formula was obtained, connecting the tension of the thread ends

$$\frac{Q_1}{Q_2} = e^{f\alpha} \qquad \left(\alpha = \int_{s_1}^{s_2} \frac{ds}{\rho}\right)$$

where α is the reduced angle of contact, ds the element of curve slip, ρ the radius of its curvature. An expression is given for α in terms of Descartes and polar coordinates. An approximate graphic method is submitted for the determination of coefficient α for the case when the curve of the thread's slip is given in the form of a diagram or a table. A formula of the same form is obtained to show the slip of the flexible link bent round a cylinder with consideration for the friction of the edge surfaces of the flanges. A detailed study is made of the differences between the formula found and the known Euler formula for the tension of the thread ends. The article finishes with a scrutiny of the picture of the deformation of a flexible bond under the influence of tension forces in a plane grip.

V. S. Novoselov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1165. Popov, B. A., Calculation of the strength and loading of nets with one side not strengthened (in Russian), *Trudi Vses. N.-i. In-ta Mor. Ryb. Kh-va i Okeanogr.* **30,** 128-145, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 452.

1166. Blamauer, O., From the three-moment law to the plate equation: Contribution to the differential calculation (in German), *Bautechnik* **35,** 7, 271-278, July 1958.

A discussion of the three-moment theorem with its applications is given. Its equivalence with the equation of equilibrium is derived by taking its most general form with arbitrarily variable and spanwise variable moments of inertia. Then a simple formula for the central deflection is obtained. It is noted that the theorem is a finite difference expression for the general second-order equation. Deflections and shears are calculated and the passage to the known fourth-order equation is explained. The last part deals with the finite difference expression for the plate equation with particular reference to supported edge conditions. Numerical illustrations are given in each case to show the power of the method.
B. R. Seth, India

1167. Amenzade, A. Yu., Solution of the problem of the deflection of open prismatic girders on EM-7 (in Russian), *Doklady Akad. Nauk. AzSSR* **12,** 2, 81-85, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5875.

Paper considers the solution of a problem dealing with the deflection of a prismatic bar by a transverse force by use of an electric model consisting of a resistance grid; the results obtained for two types of transverse sections agree with the data of the theoretical calculation; the margin of error does not exceed 3.5%.

V. K. Prokopov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1168. Fradlin, B. N., and Shakhnovskii, S. M., The stressed condition of initially bent thin rods (in Russian), *Izv. Kievsk. Politekhn. In-ta* **18,** 42-52, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4972.

1169. Strel'bitskaya, A. I., Investigation of the work of a thin-walled channel beam beyond the elastic limit (in Russian), *Sb. Tr. In-ta Stroit. Mekh. Akad. Nauk USSR* **21,** 14-26, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4735.

1170. Savruk, M. A., Deflection of a constant isotropic beam subject to an intersecting force and weakened by two unequal round cut pieces (in Russian), *Nauch. Zap. L'vovsk, Politekhn. In-ta* no. 29, 97-104, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5863.

A study is made of the deflection of a constant thin isotropic strip subject to an intersecting force and weakened by two unequal round openings; it is assumed that the contours of the openings have no external forces applied to them. Use is made of bipolar coordinates. To the basic stress function for the continuous semi-beam, a stress function is added, corresponding to a supplementary stressed condition, arising from the presence of the openings, which does not give stresses to infinity and satisfies the boundary conditions. The values of the stresses on the contours of the openings are given.
A. K. Rukhadze
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1171. Savruk, M. A., Deflection of a semi-beam, weakened by two equal round openings (in Russian), *Nauch. Zap. L'vovsk. Politekhn. In-ta* no. 29, 88-96, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5862.

The problem is studied of the deflection by a transverse force Q of a semi-beam, length l and height $2b$, weakened by two round orifices, the centers of which are situated on the beam axis at a distance $2a$ from each other. The stress function is presented in the form of

$$w = \sum_{i=1}^{3} (W_0{}^i + w_1{}^i)$$

where

$$w_0{}^1 = \frac{Q}{6I}(l - s)\, y^3, \quad w_0{}^2 = -\frac{Q}{I}xy^3, \quad w_0{}^3 = \frac{Qb^2}{2I}\, xy$$

in sum, make up the stress function for the continuous beam (axis y is placed symmetrically relative to the openings, s is its distance from the fastened end of the beam). Introducing the bipolar coordinates ξ, η

$$x + iy = a \operatorname{cth} \frac{1}{2}\, l(\xi + i\eta)$$

the author searches for function $w_1{}^i$ in the form of a Fourier series of the type

$$w_1{}^i = a(\operatorname{ch} \eta - \cos \xi)^{-1} \sum_{n=1}^{\infty} \varphi_n{}^i(\eta) \sin n\xi$$

Coefficients $\varphi_n^i(\eta)$ are determined from the equations furnished by the conditions of the absence of external loads on the openings (separately for the stresses, corresponding to $w_0^i + w_1^i$, $i = 1, 2, 3$). On the external surface of the beam the boundary conditions, as is customary, are satisfied by the circumstance that w_1^i and the stresses corresponding to it are equal to zero at infinity. Calculation for an example is given. P. P. Kufarev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1172. Anishchenko, A. F., Calculation of beams and beam plates (not isolated) on an isotropic elastic foundation in the conditions of a plane problem (in Russian), *Sb. Nauch. Rabot. Belorus. Politekhn. In-ta* no. 54, 128–138, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6027.

An examination is made of a system of beams or plates, the only connection between them appearing to be a common elastic foundation. In the arrangement of the plane problem of the theory of elasticity the question is investigated of their interinfluence. An analysis is made of the results of calculations of some systems which led to the general deduction regarding the insignificant influence of the rigidity of adjacent structures on the system under examination. A recommendation is put forward to carry out separately the calculation for each structure, and to examine the external load, applied to the adjacent structures, as a lateral additional load. P. I. Klubin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1173. Khakalo, B. P., Analysis of an elastically supported beam by the method of successive approximations (in Russian), Novelties in building construction no. 7, Kiev, Gos. Izd-volit. po Stroit. Tekhnike, 1955, 145–164; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7180.

The calculation of continuous beams is performed by the method of distributing the moments on the supports. The number of cycles of the approximation is assumed to grow with the degree of yielding of the supports; hence, the sphere of application of the method is restricted. A. G. Ishkova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1174. Rukhadze, A. K., Secondary effects in the bending problem by a couple of prismatic bars composed of different elastic materials (in Georgian), *Trudi Gruz. Politekhn. In-ta* no. 30, 93–114, 1954; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3390.

The secondary effects are examined in the problem of bending under the action of a couple for an arbitrary prismatic beam composed in a particular manner [N. I. Muskhelishvili: "Some fundamental problems of the mathematical theory of elasticity", Moscow, Akad. Nauk SSSR, 1954, Chap. VII], and made of different elastic materials. The elasticity constants (modulus of elasticity and Poisson's ratio) of the bars and the surrounding medium are regarded as being different.

The solution of the problem is constructed in the form of a stress analysis for a nonlinearly generalised form of Hooke's law, and is reduced to finding three functions of two variables, satisfying particular differential equations in partial derivatives, and the boundary conditions. A. Ya. Gorgidze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1175. Rukhadze, A. K., Problem of bending of naturally twisted prismatic beam composed of various elastic materials by a transverse force (in Russian), *Trudi Gruz. Politekhn. In-ta* **42**, 1, 65–76. 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4591.

An examination is made of the elastic equilibrium of naturally twisted sectional prismatic beam for the case when the stresses acting on the end surface $z = l$ are equivalent to the bending force.

It is assumed that the Oz axis is perpendicular to the plane of the fixed end of beam and the twist of the section z relative to this end is determined by the angle $\alpha = kz$, where k = const, the square and higher powers of which may be neglected.

Using P. M. Riz's transformation [*Izv. Akad. Nauk SSSR, Ser. Mat.* no. 4, 1939]

$$\xi = x - kyz, \quad \eta = y + kxz, \quad \zeta = z$$

the problem of bending of a twisted sectional beam studied in the space xyz is formally reduced in the space $\xi\eta\zeta$ to the problem of deformation of an ordinary prismatic sectional beam with lateral load depending, besides the variables ξ and η, on the square of the variable ζ; at the same time the equilibrium and combination equations contain complex volume forces.

Author reduces the spatial problem examined to boundary problems for harmonic and bi-harmonic functions in the case of plane component regions. The existence of solutions to these boundary problems is proved. G. M. Khatiashvili

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1176. Rozovckaya, B. A., Concentration of stresses in a number of shafts of variable section when subjected to torsion (in Russian), Issledovaniya po Vopr. Ustoichivosti i Prochnosti, Kiev, Akad Nauk USSR, 1956, 141–153; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5878.

Using the network method, a solution is obtained for the problem of the torsion of shafts consisting of two cylindrical parts of different diameters, connected by a fillet, and of shafts of round section with a ring-shaped groove. The calculations for the coefficients of concentration of shafts of the first type agree satisfactorily with the experimental data. B. N. Lopovok

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1177. Khlebutin, N. V., Tangential stresses during constrained torsion of thin-walled beams of closed-section (in Russian), *Trudi Khar'kovsk. Aviats. In-ta* no. 16, 93–108, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6065.

In the theory of constrained torsion of closed cylindrical thin-walled coverings by A. A. Umanskii [*Tekhnika Vozd. Flota,* no. 12, 1940], two approximate expressions for the tangential stresses are involved, the interrelation of which can only be attained in the integral sense. There is discussion about the approximate expression for tangential stresses, emanating from the conditions of the wall's equilibrium, and about the approximate expression for tangential stresses, determinable from the accepted picture of the deformation of a cylindrical shell [see, for instance, G. Yu. Dzhanclidze, Ua. G. Panovko, "Statics of elastic thin-walled rods," Gosstroiizdat, 1948, str. 124]. The author of the paper being abstracted, basing his ideas on the variational principle of Lagrange, deduces the original formulas of the Umanskii theory without application of the expressions for the tangential stresses of the first form, while in the practical calculations he proposes to make use only of the expressions for the tangential stresses of the second aspect, as being more accurate. It should be noted that a similar treatment of A. A. Umanskii's theory was proposed earlier by the abstractor [see "The application of variational methods for the calculations of the coverings of the wing and fuselage of an airplane," Avtorefer. Diss. Kand. Tekhn. Nauk, 1952, VVIA im. Zhukovskii]. V. V. Novitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Plates, Shells and Membranes

(See also Revs. 1166, 1199, 1201, 1270, 1306)

1178. Korenev, V. G., Some problems in the calculations of beams and plates resting on an elastic foundation (in Russian), *Sb. Trudl Mosk. Inzh.-Stroit. In-ta* no. 14, 145–167, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5908.

Two problems are examined: the problem on the calculations for beams and plates of constant thickness in an elastic zone, and for beams when taking into account the plastic deformation in the reinforcement. The solution is given first of the deflection of an unbounded plate, loaded with a transverse load and evenly stretched by constant forces p_0, acting on the median plane. The elastic foundation reacts in different ways. In particular, the foundation is substituted by an elastic semispace (with either isotropic or with a modulus of elasticity, changing in accordance with the exponential principle). The transverse load in the concrete problems is taken to be dissimilar. For instance, the load changes according to the principle $q = \cos \alpha\chi \cos \beta y$, the load is evenly distributed along the plane of the rectangle, is distributed along the straight line $y = 0$, and is applied along the circular regions. The problem of the deflection of a beam of infinite length is also examined; this beam is loaded with a concentrated force and concentrated moment following the principle $q = \alpha \cos \alpha\chi$. The possibility is indicated of calculations for beams and plates of finite dimensions, which can be obtained by cutting the unbounded beam or plate into separate parts. To continue, an examination is made of the unbounded plate resting on a continuous elastic foundation. The load applied to the plate is evenly distributed along the circle or circumference, the radius of which is small compared with unity. A calculation is made for the plate having an opening and loaded by P forces, applied along the contour of this opening. The foundation is taken to be elastic in the sense of the coefficient of the bottom layer. To begin with, the elastic problem is looked into. Plastic deformation in the ring-shaped reinforcement is taken into account with the help of the method of discontinuous solutions. Other approximate methods for the solution are also put forward.

A. G. Ishkova

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1179. Kawai, T., and Thurlimann, B., Influence surfaces for moments in slabs continuous over flexible cross beams (in English), *Publ. Int. Assn. Bridge Struct. Engng.* **17**, 117–138, 1957.

The title problem is solved for the case of a plate strip and for a continuous slab simply supported on the edges perpendicular to the cross beams. The solutions are obtained on the basis of the applicable integral equation as opposed to previous solutions based on the differential equation approach. Authors are able to obtain closed form solutions for certain special cases and to discuss singularities that exist at points for which the influence functions are determined. Numerical solutions are presented in graphical form.

M. E. Raville, USA

1180. Kuhn, R., The freely supported and uniformly loaded slab strip with partial midway-support (in German), *Forsch. Geb. Ing.-Wes.* **23**, 1/2, 11–16, 1957.

1181. Novatsky, V., Erection stresses in plates (in Russian), *Byul. Polsk. Akad. Nauk Otd. (4)* **4**, 2, 85–93, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7034.

L. M. Kurshin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1182. Facaoaru, I., Galna, N., and Nicolescu, D. D., Studies (including tests) of thin shells with double curvature. Pt. I. (in Rumanian), *Indust. Constr. Mater. Constr.* **8**, 11, 627–635, Nov. 1957.

Experimental studies were carried out by Research Institute ICIMC with new type of thin shell roofs in reinforced concrete, standardized types spanning from 12 to 24 m (36–78 ft). Three-hinged precast arched sections have rise $^1/_6$ of the span (7.2–15.6 ft) and width $^1/_{12}$ length (3–6½ ft), with constant thickness 4 cm (1¾in.). Standard reinforcing is 1.12 p.c. in longitudinal and 0.25 p.c. in transverse direction. Tests were made with quarter-size models and also on full-size structure with average span of 18 m (59 ft). Deflections under various loading (uniform, partial, concentrated) and safety factors are recorded.

J. J. Polivka, USA

1183. Rozhdestvenskii, V. V., Boundary conditions of sections of thin shells (in Russian), Issledovaniya Po Vopr. Stroit. Mekhan. i Teorii Plastichnosti, Moscow, 1956, 223–232; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5940.

In the boundary condition of equilibrium the bending moments M_1, M_2 and the longitudinal forces N_1, N_2, acting in the principal directions, are linked by a determined function. In the four-dimensional space M_1, M_2, N_1, N_2 this function determines some closed hypersurface of the flow bounding the region of the permissible stressed conditions of the shell. Author seeks the equation for this hypersurface, making use of Mises' condition of flow and variations of the principle of stress distribution according to the shell thickness, proceeding from the conditions of maximum value for one of the force factors and given values for the remainder. Such a procedure was adopted earlier for problems of a more specific nature by A. R. Rzhanitsyn ["Calculation for installations, taking into account the plastic properties of the material," Strodvoenmorizdat, 1949] and by A. A. Gvozdev ["Calculation of the carrying capacity of structures using the method of boundary equilibrium," Stroizdat, 1949]. As examples, built-up surface flows are presented for the cases of (a) a momentless stressed condition and (b) a stressed condition possessing moment in the presence of a longitudinal force.

G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1184. Kellenberger, W., Computing the strength of turbo-alternator end-bells, *Brown Boveri Rev.* **45**, 3, 113–127, Mar. 1958.

The end-bells of large turbo-alternators are heavily stressed during the overspeed test; but highly-alloy austenitic steel demands particular care from the manufacturing point of view. It is therefore essential to carry out comprehensive computation of the strength of the end-bells. The present article indicates how an end-bell may be considered as an inflexural cylindrical shell, a distinction being made between the symmetrical and the skew-symmetrical states.

From author's summary

1185. Jorgensen, S. M., Overstrain and bursting strength of thick-walled cylinders, *Trans. ASME* **80**, 3, 561–570, Apr. 1958.

A description is given of the stress distribution in elastically strained and partially overstrained thick-walled cylinders, followed by a method of determining the most advantageous degree of overstrain. Ultimate strength is discussed and an empirical formula for the bursting strength is proposed.

From author's summary

1186. Turner, C. E., and Ford, H., Examination of the theories for calculating the stresses in pipe bends subjected to in-plane bending, *Proc. Instn. Mech. Engrs.* **171**, 15, 513–525, 1957.

Paper presents a detailed theoretical study of the problem and a comparison of results with experimental evidence. It is concluded that although complete stress distributions calculated by previous

theories may be seriously in error over particular ranges of variables, the peak stresses and flexibilities are unlikely to be more than 5–10% in error if certain factors introduced in the more recent of these theories are used. Variation of geometrical shape (due to manufacturing) between nominally similar bends, however, allow predicting the behavior of a particular bend with the deviation of ±20%.

From authors' summary by V. Kopriva, Czechoslovakia

1187. Turner, C. E., and Ford, H., Stress and deflexion studies of pipeline expansion bellows, *Proc. Instn. Mech. Engrs.* **171,** 15, 526–552, 1957.

An approximate theory is introduced for the compression of a bellows, the convolution of which has a cross section formed by circular arcs subtending any semiangle. Numerical results have been calculated for two cases of the semiangle. Reasonable agreement has been stated between experimental and theoretical results. For certain design conditions optimum relationships exist between bore, wall-thickness and radius of convolution for obtaining the maximum of flexibility.

From authors' summary by V. Kopriva, Czechoslovakia

1188. Vybornov, V. G., The bending of a cylindrical panel supported on flexible inextensible ribs under the action of considerable bending deflections (in Russian), *Uch. Zap. Kazansk. In-ta* **116,** 5, 27–31, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7017.

Large bending deflections are investigated of a circularly cylindrical plate acted upon by a distributed force on the convex side. It is assumed that the panel (plate) is rigidly held at the edges by hinged ribs which are able to bend without lengthening in the plane tangential to the median plane.

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1189. Hamada, M., A suggestion regarding the problem of large deflection of plates, *Bull. JSME* **1,** 1, 20–23, Jan. 1958.

Large deflections of circular plates under uniform load are investigated by assuming uniform membrane stresses as a first approximation. The differential equation for the deflection of the middle surface is solved rigorously for the assumed uniform membrane stress, and the magnitude of the uniform membrane stress is determined from the condition of zero radial displacement at the other edge. Next, a second approximation for the membrane stresses is obtained from the condition of radial equilibrium, using the quadratic terms in the strains corresponding to the first approximation of the deflections. Results are compared to rigorous solutions by Way [*Trans. ASME* **56,** p. 627, 1934] for plate with clamped edge, and rigorous solution by Hencky [*Z. Math. Phys.* **63,** 1915] for case of vanishing flexural rigidity. Agreement of present approximate solution with these rigorous solutions is satisfactory.

W. T. Koiter, Holland

Buckling

(See also Revs. 1115, 1116, 1117, 1297)

1190. Broms, B., and Viest, I. M., Design of long reinforced concrete columns, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 4 (*J. Struct. Div.*), Pap. 1694, 29 pp., July 1958.

The design procedure presented in this paper involves the strength of a short column, the eccentricity determined from an elastic analysis, and a reduction coefficient. Depending on the method used in computing the short column strength, the procedure may be applied at either working or ultimate load level.

The reduction coefficient is based on the results of a theoretical analysis of the strength of long columns. It is shown that the strength of a hinged column with the eccentricity obtained from an elastic analysis represents a *lower limit* for the strength of restrained columns. It is shown further that the ratio of the strength of a long column to that of a short column depends primarily on the slenderness ratio and on the ratio of end eccentricities. These two variables are taken into account in the reduction coefficient.

The design procedure is compared with the available test data for hinged columns.

From authors' summary

1191. Winter, G., Lateral bracing of columns and beams, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 2 (*J. Struct. Div.*), Pap. 1561, 22 pp., Mar. 1958.

There are many situations where it is necessary to determine the characteristics required of lateral bracing in order to counteract buckling of columns or beams, or to decide whether a given bracing system is adequate to provide the required lateral support. In this paper a simple and elementary method is developed which permits one to calculate lower limits of the strength and rigidity of lateral support in order to provide "full bracing" to columns and beams. "Full bracing" is defined as equivalent in effectiveness to immovable lateral support.

From author's summary

1192. Kondo, S., Experiment on the lateral buckling of a cantilever beam with narrow rectangular cross section, *Bull. JSME* **1,** 1, 13–19, Jan. 1958.

This is a report of an experimental study for the lateral buckling of a narrow rectangular cantilever beam with an end load. These experiments were carried out systematically in a wide range of the dimension of beam. The test pieces used for the experiment were thin plates of mild steel and aluminum with varying heights and spans. The results obtained have enabled author to decide the range of beam dimension applicable to the theoretical formula of the buckling load, and also enabled him to establish an experimental formula for a range in which the old formula does not hold.

From author's summary

1193. Stussi, F., Dubas, C., and Dubas, P., The buckling of the webs of sagging beams having stiffeners in the top fifth of the web (in French, with English and German summaries), *Publ. Int. Assn. Bridge Struct. Engng.* **17,** 217–240, 1957.

A beam with I-shaped cross section is bent by terminal couples. Its web is a thin plate. To diminish the buckling danger of the web, a stiffener is applied in the top fifth of the web. The stability of this system is investigated. For this purpose the well-known differential equation of the buckling of thin plates is used. One of the boundary conditions follows from the behavior of the stiffener which is considered as a bent bar. This procedure has already been developed in several previous papers of the authors [AMR **2,** (1949), Revs. 32, 598; **3** (1950), Rev. 865] and is explained here in a more accurate manner. To obtain numerical results, the classical computing method of engineering statics is employed.

J. Barta, Hungary

1194. Haaijer, G., and Thurlimann, B., On inelastic buckling in steel, *Proc. Amer. Soc. Civ. Engrs.* **84,** EM 2 (*J. Engng. Mech. Div.*), Pap. 1581, 49 pp., Apr. 1958.

Plastic design methods assume that local buckling of flanges and webs of WF-beams will not occur during the formation of plastic hinges. Such severe conditions made the re-examination of the problem of plate buckling in the inelastic range necessary.

In contradiction to accepted opinions it was found that steel columns and plates can be compressed beyond the yield point and even into the strain-hardening range without buckling. Theoretical results for the required geometric proportions are presented

and comparison is made with experimental results obtained from tests on model columns, angles, and WF-beams.

Furthermore, consideration is given to the problem of buckling between the elastic limit and the yield stress.

From authors' summary

1195. Chatterjee, P. N., A numerical method for determination of critical buckling loads of two-hinged elastic arches, *J. Technol.* **2,** 2, 145–159, Dec. 1957.

The critical buckling load of two-hinged arches is determined by the numerical procedure of successive approximation in conjunction with the energy method to yield accurate results. A numerical example for a parabolic arch is presented to illustrate this method of computation.

E. G. Stern, USA

1196. Mulin, S. M., Spatial stability of round arches (in Russian), *Sb. Nauch. Tr. Tomskii Elektromekhan. In-ta Inzh. Zh.-d. Transp.* **22,** 102–114, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6008.

The problem is examined of the spatial stability of round arches, of constant and variable transverse section, under the action of an evenly distributed radial load, on the assumption that when loss of stability takes place the load remains parallel to the original undistorted plane of the arch. Arising from the differential equations of spatial stability of round arches, obtained by E. L. Nikolai [*Izv. Petrogradsk. Politekhn. in-ta* no. 17, 1918], and applying the graphoanalytical method with the aid of matrices, worked out by A. F. Smirnov [*Trudi. Mosk. in-ta Inzh. Transp.* no. 74, 1950] author arrives at the matrix equation for the spatial stability of the arch. The most characteristic numbers are found with the help of two-sided evaluations. A number of examples are examined of the determination of the critical parameters for double hinged and hingeless round arches of constant and stepwise variable section.

G. L. Pavlenko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1197. Borodyansky, M. Ya., Different forms of loss of stability with identical value of the critical load (in Russian), "Researches on problems of stability and strength," Kiev, Akad. Nauk USSR, 1956, 154–162; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3585.

By analysis of the determinant of the stability, it is demonstrated that in the case of a two-dimensional loss of stability of an n-sided, cyclically-symmetrical frame in compression, each critical load corresponds to an arbitrary large number of different forms of loss of stability (different characteristic patterns). This result is a development and a generalization of the relationships established by S. D. Leytess ["Design and standard," 1937, no. 8–9] for the case of a cyclically-symmetrical triangular frame in compression (case of $n = 3$).

A. A. Pikovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1198. Becker, H., Handbook of structural stability. Pt. VI. Strength of stiffened curved plates and shells, *NACA TN* 3786, 62 pp. + 1 table + 19 figs., July 1958.

This sixth part of Handbook deals briefly (2 pages) with panel instability in stiffened curved plates and is devoted for the rest to an elaborate review and discussion of general instability of stiffened cylinders. General instability in bending, including cylinders with cut-outs and optimum design for bending, under external pressure, in torsion, in transverse shear and in combined bending and torsion is treated. As far as possible, theoretical and experimental results are compared and correlated.

Paper concludes with review of state of the art, in which plea is made for additional testing to permit more reliable evaluation of theories. As usual, appendix summarizes pertinent data for design.

F. J. Plantema, Holland

1199. Genniev, G. A., and Tchaussov, N. S., An experimental investigation of the stability of metal shells (in Russian), "Investigations on problems of the mechanics of structures and the theory of plasticity," Moscow, 1956, 233–267; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7018.

Experiments are described on testing the stability of 15 samples of spherical segments under a uniform external load. Two boundary conditions were investigated: rigid and hinged support.

These spherical segments were made of mild steel by cold drawing and had radii of curvature $R = 400$ and 200 cm, a thickness of $h = 2$ and 4 mm, a rise or camber at the center of $f = 2$ and 4 cm, and a radius of the supporting ring of 40 cm.

On the basis of the experimental results, authors recommend the following approximate formulas for determining the value of the critical external, uniformly distributed pressure on a spherical segment: for the case of static (rigid) edge constraint:

$$P_{cr} = \frac{1}{3}\frac{Eh^2}{R_0^2} = 0.33\,\frac{Eh^2}{R_0^2};$$

for the case of a movable, hinged support:

$$R_{cr} = \frac{1}{9}\frac{Eh^2}{R_0^2} = 0.11\,\frac{Eh^2}{R_0^2}$$

in which E = modulus of elasticity of the material of the shell, h thickness, R_0 mean radius of curvature of the envelope.

It is pointed out that in the experiments described the arithmetic mean deviation of the theoretical value of P_{cr} from the experimental value was +2% and the mean square deviation was ±24%.

R. G. Surkin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1200. Ganiev, N. S., Determination of the upper boundary of a critical all-sided pressure on a short cylindrical shell beyond the limits of elasticity (in Russian), *Trudl Kazansk. Khimtekhnol. In-ta* no. 19–20, 317–324, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5939.

The solution of the problem given is sought in the form of (u, v, w are displacement components, h is the thickness of the shell):

$$u = A \sin n\theta \cos \frac{\alpha x}{h},\; v = B \cos n\theta \sin \frac{\alpha x}{h},$$

$$w = C \sin n\theta \sin \frac{\alpha x}{h}$$

The deformation in the shell when stability is lost is taken to be purely plastic. Assuming that n and $a = \pi\, a/l$ (a is the radius of the shell, l is its length) are represented by large numbers, a formula is deduced for the determination of the critical loading. The correlation is also given for the calculation of the value $y = n^2/a^2$. After making further simplifications for the critical bending, a simple formula is obtained; it is indicated that the error in using the formula obtained would be of the order of 6 – 7%, inclining to the decrease in value of the critical loading. From the calculations made it follows that if the parameter of hardening is $\lambda \leqslant 0.9$, then, when determining the critical loading, it is possible to make practical use of the formulas of the problem on the theory of elasticity, substituting in them Karman's modulus for Young's modulus; but when $\lambda > 0.9$ such action leads to significant error.

Yu. R. Lepik

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1201. Ollik, K. K., Stability of an elastic round cylindrical shell in the presence of large external side pressures (in Russian), *Trudl Tallinsk. Politekhn. In-ta* **A,** no. 65, 54–60, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5882.

An investigation is made of the potential energy of a shell of medium length in the transition stage from the axially symmetrical form of equilibrium to the nonaxially symmetrical form. The function of the undimensional normal deflection is taken in the form of

$$w = \left(c_1 \sin\frac{\pi R}{L}\xi + c_2 \sin\frac{3\pi R}{L}\xi\right)\cos s\theta + \frac{s^2}{4}\left(c_1 \sin\frac{\pi R}{L}\xi + c_2 \sin\frac{3\pi R}{L}\xi\right)^2$$

where θ and ξ are coordinates of the central surface in the surrounding and longitudinal directions; R and L are the radius and length of the shell, respectively. Then the stress function is determined and calculations are made for the potential energy of the shell. Energy considerations along three independent parameters c_1, c_2 and s lead to a system of algebraic equations, permitting the finding of the dependence of the potential energy of the shell on the value of the external pressure p. This dependence is presented graphically in an undimensional form. As follows from the diagram given, the nonaxially symmetrical forms of equilibrium are possible where $p > 0.63\ p^*$; when $p < 0.74\ p^*$ the potential energy of the nonaxially symmetrical forms of equilibrium becomes less than the axially symmetrical energy; here p^* is the upper critical pressure of the mean length, determined by the formula

$$p^* = \frac{0.85E}{(1-\mu^2)^{3/4}}\frac{t}{L}\left(\frac{t}{R}\right)^{3/2}$$

where t is the thickness of the shell. N. A. Alfutov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Vibrations of Solids

(See also Revs. 1273, 1325, 1443, 1570)

1202. **Haener, J., Formulas for the frequencies, including higher frequencies, of uniform cantilever and free-free beams with additional masses at the ends,** *J. Appl. Mech.* **25**, 3, p. 412, Sept. 1958.

The approximate formulas, the derivation of which is outlined, make it possible to determine immediately the n^{th} frequency of uniform cantilever and free-free beams with additional masses at the ends. From author's summary

1203. **Kappus, R., and Clerc, D., Remarks on systematizing the calculation of the natural modes of a free structure,** *J. Aero. Sci.* **25**, 4, 276-278, Apr. 1958.

A matrix method has been devised for calculation of the natural modes of a structure with a finite number of masses and taking free body equilibrium into account. This geometric matrix requires previous determination of certain matrices of geometric, mass, and elastic information. It appears that the main characteristic of this method lies in dispensing with iterative methods.

C. B. Matthews, USA

1204. **Kaluza, E., Forced vibration of elevated structures, especially in steel foundations for turbomachines** (in German), *Tech. Mitt. Krupp.* **15**, 8, 245-250, Dec. 1957.

Paper introduces the problem of vibrating complex structures consisting of floors, columns, stiffening plates, etc. It covers theory of undamped vibration, and discusses specific aspects important in the selected type of system.

R. A. Burton, USA

1205. **Raskazovsky, V. T., The oscillations of flexible structures by the action of brief inertia forces** (in Uzbeg), *UzSSR Fanlar Akad. Azboroti, Izv. Akad. Nauk UzSSR* no. 6, 89-102, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7079.

The oscillations of a flexible (elastic) cantilever bar of constant cross section are examined for the case of motions of the foundation of the bar with high acceleration, acting through a time interval brief in relation to the periods of the first five modes of free oscillation.

A distribution is obtained for the bending moments in the bar, and some conclusions are drawn concerning the behavior of elastically flexible structures under briefly-acting inertia loads.

B. K. Karapetyan

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1206. **Kropp, H., Experimental determination of torsional stiffness of medium-size and large-size crankshafts** (in German), *Maschinenbau-Technik* **6**, 11, 609-616, Nov. 1957.

Author reviews and discusses present static and dynamic methods for evaluation of the torsional stiffness of crankshafts. He proposes a new experimental method for determination of the required stiffness values. This method requires measurement of the torsional strains (electric strain gages) in the journals of the nonrotating crankshaft. These measurements are used to compute the mode of vibration and the desired stiffness. Author presents a modified Holzer Table for a step-by-step calculation of the torsional stiffness. Author claims method gives increased accuracy and efficiency. N. H. Jasper, USA

1207. **Burquest, M. O., Carpenter, J. E., and Sullivan, E. M., Structural dynamic tests of propeller blades in vacuo,** *Proc. Soc. Exp. Stress Anal.* **15**, 2, 85-96, 1958.

An apparatus for the experimental determination of static and vibratory structural characteristics of rotating scale-model propeller blades was designed, fabricated, and made operational. Concurrently with the experimental program, a method for the analytical determination of the vibratory characteristics of the coupled flatwise-edgewise bending modes of rotating, twisted blades was developed.

The model blades are rotated in a steel shell evacuated to less than 1% of atmospheric pressure. Models up to eight feet in diameter can be tested at rotational speeds up to 8000 rpm at any positive or negative blade angle setting. Provision for vibrating the blades at any pitch angle or rotational speed, as well as necessary strain-gage instrumentation, is incorporated in the installation. Photographic equipment, which is used to measure the twist or untwist of the blade tip during rotation, is an integral part of the apparatus.

The basic design features of the test equipment, special instrumentation, and typical experimental results are described. The excellent correlation between the experimental and analytical phases of the program is noted.

From authors' summary

1208. **Kumai, T., Damping factors in the higher modes of ship vibration,** *Rep. Res. Inst. Appl. Mech., Kyushu Univ.* **6**, 21, 25-34, 1958.

Author analyzed theoretically the damping force due to normal and tangential viscosity and the external damping force, and compared the results with the values obtained from actual ship measurements. The theoretical results showed good agreement with the following empirical formulas:

$$\delta_{2-v} = C/L,\quad \delta_{n-v} = \delta_{2-v}\,(N_n/N_2)^{3/4}$$

where δ_{2-v}, δ_{n-v} are logarithmic decrements in 2-node and n-node vertical vibration in ballast condition; $C = 3 \sim 4$; L = length of

ship in meter; N_2, N_n = natural frequencies of 2-node and n-node vertical vibration in ballast condition.

As the components of the damping factors, the following results was drawn: (1) The damping factor due to normal viscosity is almost constant. (2) The damping factor due to tangential viscosity is proportional to the natural frequencies. (3) The external damping factor is negligible. T. Kanazawa, Japan

1209. Kroll, Wilhelmina D., Effect of rib flexibility on the vibration modes of a delta-wing aircraft, *J. Res., Nat. Bur. Stands.* **60**, 4, 335–341, Apr. 1958.

Modes and frequencies are computed for a basic configuration and for various modifications, involving elimination of some ribs or reduction of rib bending stiffness. Results indicate effect of rib stiffness on frequencies and mode shapes to be small, particularly for lowest three symmetrical and antisymmetrical modes.

G. Isakson, USA

1210. Pisarenko, G. S., The influence of grain size on energy dissipation in a vibrating material (in Russian), *Izv. Kievsk. Politekhn. In-ta* **17**, 316–320, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3728.

The influence of grain size on the logarithmic damping decrement is investigated on impact samples of Armco iron of prismatic form, 210 × 20 × 5 mm, which had a grain size of 40 and 70μ respectively.

The oscillograms were recorded on a loop oscillograph with a photocell as the transmitter. The author comes to the conclusion that the material of larger grain has a higher damping decrement than the finer-grained material; the difference increases with the stress amplitude and amounts to 40% at a stress value of 7 kg/mm^2.

The author is of the opinion that the energy dissipation in the material proceeds principally by microplastic deformation at the grain boundaries, and that in the case of larger grains under higher stress, the plastic deformations are of greater magnitude than in the fine-grained samples.

In the case of materials of pronounced inhomogeneity, e.g. with graphitic inclusions, the grain size has an even greater influence on the damping decrement of the sample.

D. M. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1211. Arnold, J. S., and Martner, J. G., Method for analyzing vibration at a surface point, *Rev. Sci. Instrum.* **29**, 9, 779–783, Sept. 1958.

A biaxial vibration pickup is described. Pickup is for making measurements necessary to evaluate constants which appear in the parametric equations of motion of a point on a vibrating surface. Pickup probe is a fine wire bent into a right angle. Corner of wire is point of contact with vibrating surface. Two ends of wire bear against barium titanate transducers. Thus pickup measures amplitudes and phase difference of two components of motion at right angles to each other. Transverse motion of probe is said to produce only 2.3% of signal produced by longitudinal movement. Measurements made on a barium titanate disk are given as examples of instrument capability.

E. A. Ripperger, USA

1212. Fridman, V. M., An approximate method for determining vibration frequencies (in Russian), Kolebaniya v Turbomashinakh, Moscow, Akad Nauk SSSR, 1956, 69–76; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5930.

An approximate solution is offered for the determination of the free flexural vibrations of a bar of variable section, providing for different conditions for the end fastenings (fastened, freely supported, free ended). When solving the differential equations for the problem

$$M''(x) = [\lambda^2\rho(x) + k(x)]\,Y(x) \qquad (0 < x < l)$$
$$Y''(x) = \frac{M(x)}{EI(x)}$$

it is recommended to assign not only the form of vibration $Y(x)$ as usual by Bubnov's method but also the form of the bending moment $M(x)$, which, the author asserts, increases the accuracy of the calculation. The approximate determination of the first n frequencies of free vibrations of the rod in this manner merges with the determination of the parameter value λ, converting to zero the determinant of the system from n linear homogeneous equations, obtained by the given method. The application of the method is the subject of two illustrative examples: (1) the determination of the first frequency of vibrations of a turbine blade and (2) the determination of the critical velocity of an electric motor's rotor. I. M. Volk

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Wave Motion and Impact in Solids

(See also Revs. 1148, 1158, 1321)

Book—1213. Flammer, C., Spheroidal wave functions, Stanford, Calif., Stanford University Press, 1957, ix + 220 pp. $8.50.

Author presents a brief but adequate introduction to the theory; discussion of physical applications; extensive tables of functions, eigenvalues, and expansion coefficients. Excellent bibliography is given. W. A. Mersman, USA

1214. Plass, H. J., Jr., Some solutions of the Timoshenko beam equation for short pulse-type loading, *J. Appl. Mech.* **25**, 3, 379–385, Sept. 1958.

Solutions (by method of characteristics and Laplace transform) are given of Timoshenko's equation for dynamics of beam flexure. Validity of theory is established by experiment, except for pulse loading of extremely brief duration.

R. E. D. Bishop, England

1215. Duvall, G. E., Pressure-volume relations in solids, *Amer. J. Phys.* **26**, 4, 235–238, Apr. 1958.

Author, using conventional thermodynamic techniques, derives relations for the pressure-volume dependence during isentropic and shock compressions of a substance whose equation of state is of the form

$$p = f(V) + T\,g(V)$$

He makes the additional restriction that the constant volume specific heat is temperature independent. Noting that equations of the given form are appropriate to solids, he applies the derived relationships for the isentrope and Hugoniot relation to the Murnaghan equation of state. The constants for the Murnaghan equation for a number of metallic elements are tabulated.

W. Daskin, USA

1216. Knopoff, L., Fredricks, R. W., Gangi, A. F., and Porter, L. D., Surface amplitudes of reflected body waves, *Geophysics* **22**, 4, 842–847, Oct. 1957.

Numerical computation of the reflection of P and SV waves at the free surface of the elastic half space is performed. Amplitude at the surface is given as the function of the incident angle with the values of Poisson's ratio (0.5, 0.4, 0.3, 0.25, 0.2, 0.1, 0) as the parameter. For the case of incident SV waves with an incident

angle larger than the critical value, phase shift angle is also given. Similar study was done by H. Jeffreys [M.N.R.A.S., Geo. Sup., 1, 1926], T. Matuzawa [*Zisin* **4,** 1932] and B. Gutenberg [*Bull. Seism. Soc. Amer.* **34,** 1944], but not with such a wide range of Poisson's ratio.

Y. Sato, Japan

1217. Balandin, Yu., and Bolonov, I., A method of analysing longitudinal impact (in Russian), *Sb. Rabot Stud. Nauch. O-va Penzensk. Industr. In-ta* no. 2, 3–7, 1956; *Ref. Zh. Mekh.* no. 3, 1957, Rev. 3467.

1218. Lankin, R. P., Dynamic stability of round bars (in Russian), Avto refer. diss. kand. fiz.-matem. Nauk, Lengr. politekhn. in-ta, Leningrad, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6216.

1219. Kisselev, V. A., The dynamic influence lines of the displacements and internal forces in beams, frames and slabs, simply and elastically supported, under the action of a load moving with uniform velocity (in Russian), *Trudi Mosk. Avtomob.-dor. In-ta* no. 18, 139–171, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7080.

The oscillations of a single-span girder on elastic Winkler foundations are investigated on the assumption that the reactive forces are proportional to the rate of displacement of the girder. The inertia forces of the foundation and the live load are not considered. The solution of the initial differential equation is found by the method of initial parameters, the general case of constrained oscillation being examined in the first instance. Further, an equation is given for the influencing lines of the displacements and the internal forces in the girder. It is also shown how the method described for the example of a single-span girder can be applied to the case of trusses or continuous beams.

The oscillations of rectangular plates are examined similarly.

N. I. Bezukhov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1220. Hart, E. W., An uniaxial strain model for a Luder's band, *Acta Metall.* **3,** 2, p. 146, Mar. 1955.

Author proposes a simple uniaxial model for the propagation of Luder's band at a steady-state velocity at constant load. He derives a differential equation, relating the strain to the position in the band, which may be solved when a unique stress-strain strain-rate relation is given, the velocity of propagation is given, and appropriate boundary conditions are prescribed at the head and the tail of the band. Author also rationalizes the load-elongation yield point behavior in terms of the functional dependence of band velocity on applied load.

G. Horvay, USA

1221. Lambert, J. W., On the nonlinearities of fluid flow in nonrigid tubes, *J. Franklin Inst.* **266,** 2, 83–102, Aug. 1958.

Several discrepancies between linear theory and experimental results are explained by the nonlinear theory. Two simultaneous nonlinear differential equations are considered for the nonsteady one-dimensional motion of an ideal fluid in a rotationally symmetric tube. To these must be added an equation of state expressing the tube radius as a function of the pressure difference. The general solution of these equations for a linearly elastic tube is expressed in an analytic form convenient for computation on a digital computer. A graphic method of solution is also presented and applied to the problem of a large pulse wave in a semi-infinite tube. Data for the problem presented are intended to simulate the problem of the heart pulse wave in the aorta.

R. C. Binder, USA

1222. Kompaneets, A. S., Shock waves in a plastic compactible medium (in Russian), *Doklady Akad. Nauk. SSSR (N.S.)* **109,** 1, 49–52, July 1956.

Expressions are found for time and maximum radius of affected zone due to explosion in small cavity of a medium such as loose sand having an initial density ρ_0, no bulk modulus until the density ρ_1 is reached when it becomes incompressible, and a yield criterion increasing with pressure. Confusion between initial radius of cavity, R_0, and current inner radius of dense material in Eqs. [9] and [10] seems not to affect subsequent analysis.

F. A. McClintock, USA

1223. Symonds, P. S., and Mentel, T. J., Impulsive loading of plastic beams with axial constraints, *J. Mech. Phys. Solids* **6,** 3, 186–202, May 1958.

Paper concerns plastic deformations of simply supported and clamped beams whose ends are prevented from displacing axially, and which are subjected to transverse impulsive pressure loading. Solutions are based on a rigid-plastic type of analysis in which elastic deformations are disregarded as negligible by comparison with plastic ones. This approach is held to be appropriate if the energy absorbed in plastic deformation is very large compared to the maximum energy the structure could absorb in an elastic manner. Finite axial forces arise as soon as the beam acquires a finite deflection. In the final stage, deformations are primarily governed by catenary effects. It is shown that when deflections reach the order of the beam thickness, the treatment as a simple beam becomes unrealistic, the deflections being much smaller than those predicted by a treatment where axial forces are disregarded.

From the authors' summary by B. Gross, Brazil

1224. Voloshenko-Klimovitskii, Yu. Ya., Elastic-plastic expansion processes due to impacts (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 147–150, Apr. 1956.

Soil Mechanics: Fundamental

(See Revs. 1222, 1602, 1612)

Soil Mechanics: Applied

(See also Rev. 1204)

1225. Vesic, A., Study of vertical and inclined pile foundations (in French), *Ann. Trav. Publics Belg.* no. 6, 5–77, Dec. 1956.

In the design of pile groups, consisting of vertical piles acted upon by horizontal forces and moments, the present practice takes into account the lateral resistance of the soil and the rigidity of the pile as well; it neglects them, however, in the case of inclined piles. In this paper author proves that a slight lateral resistance influences greatly the distribution of the resulting force between the individual piles. He works out a procedure for computing this distribution with regards to this lateral resistance. His assumptions are conservative: there is linearity between forces and displacements. Two characteristic lengths are introduced: the ratio between the values of the moment and the horizontal force acting on the fixed pile head; and the ratio between the horizontal displacement and rotation of a pile head acted upon by horizontal force. The ratio of these lengths varies between narrow limits. Between this ratio and the factors of proportionality between pile forces and displacements and rotations respectively, three simple relations can be established. Determining the elastic center of the system, the linear combinations of the components of the resulting force, shifted in this point, give the components of the pile loads. The factors of proportionality had been determined as influence values; for two arrangements of piles author gives detailed tables for them. In the third part of the paper

author tries to bring into relation the factors mentioned above—the first characteristic length, ratio of the characteristic lengths, the ratio between axial and lateral load and the corresponding displacements—and the coefficient of lateral subgrade reaction. He determines the minimum value of pile length and investigates the influence of the deformation characteristics. Two detailed numerical examples illustrate the presented method of computation.

A. Kezdi, Hungary

1226. Lipovetskaya, T. F., Experimental investigation on the distribution of stresses over the bed plates of rigid punches, erected on a sand foundation (in Russian), *Sb. Trudi Mosk. Inzb. Stroit. In-ta* no. 14, 216–220, 1956; *Ref. Zb. Mekb.* no. 5, 1957, Rev. 5983.

Results are given of experiments for the establishment of the distribution of stresses below a rigid punch on a sand foundation under conditions nearing those for the plane problem. The experiments were carried out with dry sand of medium particle size and density: $y = 1.65$ tons/m^3 in a large trough 6.5×5.5 m in area and a depth of 3 m and in a small trough 3×2.75 m with a depth of 2 m. In the large trough three square punches were placed side by side, with sides $b = 1.42$ m; in the other, with sides $b = 0.7$ m.

The measurement of stresses in the soil foundation was made for the central punch with dynamometers of the Bombchinsk system and dynamometers with transmitters of Ohm resistance, placed in the large trough at a depth of 4–5 cm and in the small one at 2–3 cm from the surface. The pressures by degrees reached the destructive loading point of 4 kg/cm^2 in the small trough and in the large up to 2.5 kg/cm^2. The distribution of the stresses was found to be parabolic, while the relation of the maximum pressure in the center to the mean pressure σ increased with the relation σ/by for the punches of both sizes according to one and the same principle. It was demonstrated that the experimental curves at loads close to the destructive loads differed but slightly from the theoretical established by the abstractor [*Inzbener. sb.* **12**, 1952] when solved in the first approximation of the combined problem of the theory of elasticity and the theory of the boundary condition of a friable medium. The author holds the opinion that the results obtained show the unsuitability of applying the hypothesis of the elastic half-space to the calculations of structures on a sand foundation; a better convergence with experimental data should be sought from the solution of the combined problem or by using for the sand the model of a nonlinear medium subject to deformation.

M. I. Gorbunov-Posadov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1227. Mintskovskii, M. S., Approximate solution for wedge-shaped foundations of buildings erected above mine workings (in Russian), Novoe v Stroit. Tekhniki, no. 7, Kiev, Gos. Izd-vo Lit. po Str-vu i Arkhitekhture, SSSR, 1955, 165–177; *Ref. Zb. Mekb.* no. 5, 1957, Rev. 5982.

A plan is examined in which the contact of the substructure of the building with the foundation is broken in the central portion, while two side portions of the foundation are supported by the soil. On the assumption that in the side portions of the central part the soil is in a state of boundary equilibrium, a determination is made of the length of the central part. The substructure is looked upon for purposes of calculation as a beam with fastened ends.

P. M. Varvak

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1228. Vlasov, V. Z., and Leont'ev, N. N., Technical theory of calculations for foundations on an elastic base (in Russian), *Sb. Trudi Mosk. Inzb.-Stroit. In-ta* no. 14, 12–51, 1956; *Ref. Zb. Mekb.* no. 5, 1957, Rev. 5979.

As the model of the elastic base use is made of a vertical rectangular plate with height H. The beam rests on the upper longitudinal edge, while the lower edge of the plate is supported on an incompressible base.

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1229. Kalinskii, B. V., Calculations for annular tunnel linings, placed in loose soils, by the closed method (in Russian), *Tr. Bezbitsk. In-ta Transp. Masbinostr.* no. 14, 153–187, 1955; *Ref. Zb. Mekb.* no. 5, 1957, Rev. 5993.

For the determination of the internal forces and deformation the known differential equation for a ring lying on an elastic foundation is made use of. The solution of the differential equation is examined for various cases of the work of the tunnel lining by the method described by A. P. Korobov [*Izv. Novocberkassk. Industr. in-ta*, 1941]. Examples of the calculations are given.

I. V. Fedorov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1230. Kondrat'ev, V. N., Plotting hydrodynamic lattices for symmetric aprons and foundation ditches (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekb. Nauk* no. 11, 113–116, Nov. 1956.

Processing of Metals and Other Materials

(See also Revs. 1487, 1587)

1231. Takeyama, H., and Usui, E., The effect of tool-chip contact area in metal machining, *Trans. ASME* **80**, 5, 1089–1096, July 1958.

See AMR **11** (1958), Rev. 2636.

1232. Zlatin, N., and Gould, J. V., The effect of a lead additive on the machinability of alloy steels, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-53, 5 pp.

1233. Kienzle, O., and Kienzle, W., Tool wear in the cutting of steel sheets (in German), *Stahl u. Eisen* **78**, 12, 820–828, June 1958.

1234. Iwaki, A., and Mori, M., Factors generating surface roughness in cutting, *Bull. JSME* **1**, 1, 86–94, Jan. 1958.

Surface roughness in brass, copper, mild steel, hard steel and cast iron is compared for different cutting conditions by means of correlation coefficient.

B. W. Shaffer, USA

1235. Impact extrusion, *Metal Treatm.* **25**, 150, 107–110, Mar. 1958.

1236. Buhler, H., and Schepp, W., Effect of internal stresses in hardened tool steels on the development of grinding cracks (in German), *Stahl u. Eisen* **77**, 23, 1686–1690, Nov. 1957.

Fracture (Including Fatigue)

(See also Revs. 1185, 1224, 1260, 1263, 1272, 1313)

1237. Rey, W. K., Cumulative fatigue damage at elevated temperature, *NACA TN* 4284, 20 pp. + 18 tables + 7 figs., Sept. 1958.

A study of cumulative fatigue damage at elevated temperatures was conducted using heat-treated SAE 4130 alloy steel. The *S-N*

curves at room temperature, 400 F, and 800 F were obtained from rotating-beam fatigue tests. Two-step, three-step, and five-step cumulative-damage fatigue tests were conducted on rotating-beam fatigue specimens at room temperature, 400 F, and 800 F. The results of the cumulative-damage tests are compared with those of a theoretical analysis. From author's summary

1238. **Valluri, S. R., Some observations relating to recovery of internal friction during fatigue of aluminum,** *NACA TN* 4371, 14 pp. + 1 table + 10 figs., Sept. 1958.

Recovery of internal friction during periods of rest in specimens subjected to fatigue stresses in torsion has been studied experimentally with high-purity aluminum. The effective heat of activation for the process is found to be about 10,000 calories per gram molecule or less. The idea is presented that the dislocations responsible for the recovery of internal friction are the same as those responsible for fine slip which, according to one existing theory, is the mechanism responsible for fatigue failure. Experimental results indicate that obtaining a recovery factor independent of stressing history may possibly be associated with installing a cyclic process in which the subgrain structure is well established. The basic process then occurring may be one of indefinite to-and-fro motion of some free dislocations within a framework of immobilized arrays of dislocations responsible for the general plastic flow and the substructure.

From author's summary

1239. **Walker, P. B., Fatigue of a nut and bolt,** *J. Roy. Aero. Soc.* **62,** 570, 395-407, June 1958.

1240. **Low, A. C., The fatigue strength of pin-jointed connections in aluminum alloy B. S. L6$_1$,** Instn. Mech. Engrs., Prep., 11 pp., 1958.

The purpose of this paper is to report investigations into the improvements in fatigue strength of pin-jointed assemblies that could be obtained by the use of interference fits between pin and lug, and the effect on the strength of variations in pin diameter.

Direct-stress tension-tension-fatigue determinations were made on assemblies consisting of an aluminum-alloy lug joined to a steel fork by means of a hardened-steel pin, using one over-all size of lug, and varying first the pin size (using a constant percentage interference) and then the degree of interference (using a constant pin size). Tests were also made on lugs fitted with interference-fit steel bushes and sliding-fit pins.

For the over-all size of lug tested ($2\frac{1}{4}$ in. × $\frac{3}{4}$ in., pin center $1\frac{1}{2}$ in. from the end) the optimum pin size was found to 1 in. diameter, and the optimum interference on a 1-in. pin was found to be 0.007 in. Joints with such a pin had a fatigue strength at 10 million cycles of about $\frac{1}{4}$-$9\frac{1}{2}$ tons load as compared with $\frac{1}{4}$-$1\frac{1}{2}$ tons load using a sliding-fit pin. Bushed lugs gave similar results.

From author's summary

1241. **Shapiro, E. A., Fatigue tests on nonstandard samples** (in Russian), *Zavod. Lab.* **20,** 5, 602-603, 1954; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7354.

Author suggests that fatigue tests on nonstandard samples of individual components should be made on an NU-type machine.

The use of a dynamic strain gage for measuring deformations and stress values enables the necessary conditions to be established for testing nonstandard samples for which it is difficult to estimate the stresses arising during fatigue testing.

S. A. Borisenko
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1242. **Bartenev, G. M., and Galil-Ogly, F. A., Mechanism and conformity to rule of the dynamic fatigue of rubbers** (in Russian), Ageing and fatigue of caoutchoucs and rubbers and enhancement of their stability, Leningrad, Goskhimizdat, 1955, 119-129; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6197.

A study is made of the fatigue process of rubber made from caoutchouc SKS-30, both for the given loading and for the given maximum elongation. Emphasized is the coincidence of these processes with the behavior of rubbers subjected to prolonged static loading and of metals under repeated loadings. It is shown how strong is the dependence of the resistance of rubbers to repeated loadings on the chemical processes taking place in the material being tested. The course taken by these processes depends on the conditions of test and the properties of the material.

L. A. Vishnitskaya
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1243. **Frederiksen, M., Shear rupture in reinforced concrete beams** (in English), *Ingenioren (B)* **67,** 12, 388-393, June 1958.

The influence of shear forces in use of failure theories for design of concrete structures has not been adequately clarified in previously reported research. Author considers that "the compression zone of reinforced concrete contributes to the shear resistance and . . . rupture of this zone is generally the cause of the collapse of the member . . ." In the present article, an attempt has been made to establish a theoretical analysis . . . "based on stress-strain curves of the materials and Mohr's rupture envelope for concrete." Calculations, on the basis of simplifying assumptions, are shown for a simply loaded beam and, in illustration, applied to results of experiments described in a referenced previous paper. The ideas suggested in the paper may be useful guides in further experimental research. H. J. Grover, USA

1244. **Orner, G. M., Charpy brittle-fracture transitions by the lateral expansion-energy relationship,** *Welding. J.* **37,** 5, (Research Suppl.), 201-s-205-s, May 1958.

Data presented show that the brittle-fracture transition temperature correlates with the low-blow transition temperature, provided the effect of adiabatic temperature rise is taken into consideration.

From author's summary

1245. **Chi, M., and Kirstein, A. F., Flexural cracks in reinforced concrete beams,** *J. Amer. Concr. Inst.* **29,** 10, 865-878, Apr. 1958.

A new concept is introduced into the problem of crack formation in reinforced-concrete beams subjected to pure flexure, along with simplified semiempirical equations for the determination of the average minimum spacing and the average width of cracks in the concrete. Historical background given leads to development of the analysis and the assumptions incorporated in it. To verify the analysis, crack data from 16 test specimens are presented and used to augment the data from previous investigations.

From authors' summary

1246. **Vedeler, G., One learns from bitter experience—some instances of damage caused by fracture in recent years,** *Inter. Shipbldg. Prog.* **5,** 42, 67-77, Feb. 1958.

1247. **Winterton, K., Mechanism of microcracking in mild-steel welding,** *Welding J.* **36,** 10, (Research Suppl.), 449s-556s, Oct. 1957.

Microcracking, characteristic of metal-arc mild-steel weld metal, has been observed in the weld metal from a number of different electrodes available in Canada. Considerably less microcracking was found with low hydrogen basic-coated types.

The effect of several variables on the incidence of microcracking has been examined and discussed. Special attention has been given to the types of nonmetallic inclusions present and to their role in microcracking.

A general theory is put forward to account for microcracking (and the closely related phenomenon of halo-formation) in terms of the accumulation of hydrogen under pressure in pre-existent flaws; specifically, incipient hot cracks and also misfits at the boundaries of nonmetallic inclusions. The phenomenon of hydrogen diffusing out of weld metal from these exit points is illustrated.

From author's summary

1248. Balavadze, V. K., Some questions on crack formation in light ferro-concrete (in Russian), *Soobshch. Akad. Nauk. GruzSSR* **17**, 4, 329-336, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6091.

Diagrams of the deformation (up to the point of disruption) of light concretes are submitted when under axial tension and deflection; these showed a significant local flow near the cracks. By means of strain-gage readings the zonal dimensions of the flow were obtained, and it was established that the changes of clean plastic relative deformations of tension ε_p, along the length of the zone of flow, obeyed the linear principle. The bond of the maximum boundary value of ε_r (at the point of formation of the crack) and its mean value was found on the long side of the zone of flow. A formula for the calculation of the force at the moment of appearance of cracks in the tufaceous ferro-concrete cross bars under tension (with different degrees of reinforcement) is submitted; descriptions of the test results for deflection are given and formulas for calculation of the bending moment corresponding to the appearance of the cracks are brought in.

Yu. I. Likhachev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Experimental Stress Analysis

(See also Revs. 1241, 1265, 1334, 1437)

1249. Fessler, H., and Haines, D. J., A photoelastic technique for strain measurement on flat aluminium alloy surfaces, *Brit. J. Appl. Phys.* **9**, 7, 282-287, July 1958.

A technique is described for bonding layers of an epoxy resin on flat aluminum-alloy surfaces. Joints which withstood more than 4% strain were obtained by carefully controlled preparation of the metal and the adhesive. Initial birefringence was avoided by curing the joint without external pressure and by slow cooling after finish curing at 65 C.

The different types of reflection polariscopes are discussed, the strain fringe values for the reflecting layer and for the adhesive are estimated. A test of a lug describes an application of the method.

From authors' summary

1250. Kammerer, A., and Lamare, A., Three-dimensional photoelasticity (in French), *C. R. Acad. Sci., Paris* **246**, 17, 2457-2459, Apr. 1958.

1251. Giatsintov, E. V., Investigation of stresses by means of an optical-polarizing method when residual stresses are present in the model (in Russian), *Trudi Mosk. Aviats. Tekhnol. In-ta* no. 25, 92-102, 1954; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6165.

Making use of the stepwise loading and the linear relation between σ_x, σ_y, τ_{xy} and the external loading, it is possible to exclude the residual stresses in the process of working over the experimental data, which enables the investigation of stresses to be carried out in models with considerable residual stresses. To confirm this an example is examined of a plate with hyperbolic grooves when central tension is operating. After excluding residual stresses situated in the model, the difference between the nominal stresses obtained by experiment and theoretically (according to Neiber) does not exceed 8%.

V. D. Kopytov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1252. Okubo, S., Durelli, A. J., and Dally, J. W., A dynamic strain calibration device, *Proc. Soc. Exp. Stress Anal.* **15**, 2, 67-72, 1958.

Paper describes a dynamic loading device and an electronic timer which were used in a study of the dynamic properties of Stresscoat. The device employs a cantilever beam as a calibration member ($\frac{1}{4} \times 1 \times 6$ inches) and requires about 8 milliseconds to impose a maximum strain of 1200 microinches/inch on the beam. The time of maximum load application can be varied from 7 milliseconds. The device produces a nearly square form of a strain-time trace.

The constuction, modifications, and evaluation testing on the loading device are discussed. The circuitry of the timer and its operation are also covered in some detail.

From authors' summary

1253. Prigorovskii, N. I., Vasiliev, A. A., Bortkevich, V. I., and Daichik, M. L., Wire strain gauges (in Russian), Changes of stresses and forces in machine parts, Moscow, Mashgiz, 1955, 5-43; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6120.

The properties of a wire strain gage are described; for hard and annealed constantan and nichrome, experimental curves are produced showing the relations of the stresses and the relative change in electric resistance from the relative elongation (up to $\varepsilon = 0.8\%$). Investigations are carried out on the transfer of forces from the machine part to the gage taking into account the flexibility of the adhesive. Analyses, formulas and curves are presented for the selection of the thickness of wire, of the current and resistance of the gage, when considering the type of electric measuring instrument used, of the result of analysis of a number of methods designed to protect the gages from humidity, and of the experimental curves for the creep of the glue because of the increased temperature of the gage. Data are given of the margin of error because of the mechanical hysteresis for gages, glued on with different glues; formulas are advanced for the maximum length of the gage when recording high frequency dynamic deformations; a summary is given of the properties of the materials from which strain-sensitive wires are made and also a number of recipes for glues.

The technology and constructional details for making wire strain gages are described, and also the making of gages for measurements at temperatures up to 800°. Three types of electronic tube apparatus are described for work with wire strain gages: (1) A full schematic plan with data for all the components of the measuring device of the type ISD [Instituta mashinovedeniya Akad. Nauk SSSR] on valves 6H2P, 6H1P, 6X2P and 6Ts4P, with a sensitivity to deformation of 10^{-5} cm/cm and feed of the measuring bridge of 50 hertz frequency. (In the ISD scheme put forward there is a mistake: it is essential to exchange the places of inclusion of the anodes of the valve 6X2P. Note by the abstractor.) (2) A full schematic plan for automatic registration of static deformation at 120 points in the course of 80 secs; also given is the design for a commutator with 120 points. (3) A summary of parameters of high sensitivity frame vibrators from the factory "Geofizika" on currents from 500 to 2 μ A on full deflection, and a detailed description of a strain-gage plant type UD-3 for dynamic strain gage readings up to a frequency of 1500 hertz. Some brief particulars are given of the cathode oscillograph apparatus for the recording of deformation due to impact.

P. V. Novitskii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1254. Magin, I. Ya., Methods for the experimental determination of stresses and forces in machine parts (in Russian), Reduction in weight and the improvement in quality of machines, Moskva-Sverdlovsk, Mashgiz, 1955, 82–109; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6118.

Author concentrates his study on the details of application of wire transmitters of resistance. Two devices are described for their production. The geometrical and physical features of transmitters are described. In preparing and utilizing transmitters, adhesives Nos. 192T and BF-2 are used, the latter up to 200°. Good keeping qualities for transmitters are insured by covering them first with paraffin wax and then with vaseline. To make it possible to use the transmitters repeatedly they were not prepared on paper but on brass or steel foil (thickness 0.07–0.1 mm), which is attached to the part with celluloid adhesive. For a second use of such a transmitter it was detached from the part by means of a razor blade. When used repeatedly (up to 20 times) the divergence of readings was 3% of the mean value of the stress. Data are given for the utilization of multilayer transmitters (5–10 transmitters, glued together, layer by layer) which are interesting from the point of view of the ability to obtain transmitters of small bases and large resistance. Test results showed some increased values for deformation for the topmost transmitter.

The investigation on the temperature characteristics of the constantan wire used for transmitters was reported. The temperature coefficient of the constantan resistance after annealing at 200° diminishes and stabilizes. Annealing at 300–350° brings the temperature coefficient of resistance to values approaching zero. The sensitivity of the transmitters at different temperatures is determined. With increases of temperature from 20 to 200° the sensitivity of transmitters glued onto a steel beam decreases by 8%.

Then a piece of apparatus is described which measures both static and dynamic loading. A design is submitted for a 50-point scheme. The measurements are carried out on the zero method by means of a drum rheochord, having a hundred divisions to each revolution. As indicator, use is made of either a microammeter M-91 or an electronic galvanometer, representing a three-cascade amplifier with vibrotransformers at inlet and outlet, working synchronously. For the measurements with dynamic loading, an amplifier is employed, with amplitude modulation on the carrier frequency of 2000 hertz, and with a phase sensitive detector on the ring system. The methods for utilizing wire transmitters for measurement of forces and weights are described and examples are given. A double component dynamometer is constructed for the measurement of the cutting force of a turning lathe, crane electroweighing machines for loads up to 50 tons, and electrodynamometers up to 200 tons, etc. N. P. Raevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Material Test Techniques

(See also Rev. 1210)

1255. McSkimin, H. J., Elastic moduli of single crystal germanium as a function of hydrostatic pressure, *J. Acoust. Soc. Amer.* **30,** 4, 314–317, Apr. 1958.

The adiabatic elastic moduli of single-crystal germanium are reported as a function of hydrostatic pressure to 50,000 psi, and for a temperature range of 0–75 C. The variation with pressure of bulk modulus is found to compare favorably with isothermal values obtained by P. W. Bridgman. The techniques used for measurement are detailed. From author's summary

1256. Brown, D. C., A variable delay line, *Coll. Aero. Cranfield Note* no. 81, 6 pp. + 2 tables + 8 figs., Jan. 1958.

A variable delay line has been designed and built which can be used as an accurate means of measuring time intervals between 10 and 200 μ seconds. The use of such a device for the determination of the temperature coefficient of Youngs' modulus is described. From author's summary

1257. Noren, B., and Saarman, E., Shear tests on plywood (in Swedish), *Sven. TraforskInst. Medd.* 93 B, 17–22, 1958.

The investigations show that results with considerable variance are obtained if different methods for testing the shearing strength of plywood are employed. This is particularly the case with the shear modules.

The method according to ASTM which, like method I of the present paper, appears in the FAO standards, yields, for instance, rather high shear module values which are mainly due to the eccentricity of the application line of the shearing power in relation to the actual edges of the specimens. Methods by which the eccentricity of the power is avoided seem to yield shear values which correspond more closely to the properties of wood.

From author's summary

1258. Fessler, H., A tensile strut testing machine, *J. Roy. Aero. Soc.* **62,** 571, p. 528 (Tech. Note), July 1958.

1259. Philleo, R., Some physical properties of concrete at high temperatures, *J. Amer. Concr. Inst.* **29,** 10, 857–864, Apr. 1958.

Experimental techniques are described and data are presented on the thermal expansion, density, and dynamic modulus of elasticity of concrete in the range 75–1500 F. Such information is necessary to evaluate stresses due to nonuniform heating which could result from a building fire or jet aircraft blast. The results indicate that weight loss due to loss of water is substantially complete at 800 F. At higher temperatures changes in weight are determined by the chemical nature of the aggregates. The coefficient of expansion increases above 800 F, since expansion is no longer inhibited by drying shrinkage. At 1400 F the modulus of elasticity is reduced to less than half its value at 75 F, the exact reduction depending on the extent to which hydration had progressed at the time of exposure.

From author's summary

1260. Owen, N. B., and Cox, H. L., Slipping-clutch fatigue-testing machine, *Engineering* **186,** 4819, 84–85, July 1958.

1261. Jobling, A., and Roberts, J. E., Mechanical testing of materials in the transition region between steady flow and failure, *Brit. J. Appl. Phys.* **9,** 6, 235–239, June 1958.

An attempt has been made to overcome some of the defects of the standard methods of mechanical testing of materials. The new method, in which the deformation is brought about by attaching the specimen to a substrate, shows that, when the final mechanical failure occurs, continuity is preceded by a region of disturbed flow in which the flow lines appear as a pattern of remarkable regularity, the direction of which is not that of maximum shear.

Materials such as dry powders, pastes, polymers and vacuum-deposited metals have been studied and show unexpected common features, e.g. fatigue and relaxation of work-hardening by vibrations From authors' summary

1262. Willetts, C. H., Investigation of the Schmidt concrete test hammer, *Wwys. Exp. Sta. Misc. Pap.* 6–267, 11 pp. + 5 tables + 4 plates, June 1958.

Tests were made to evaluate the readings (indicating quality and strength) obtained with the Schmidt hammer on hardened concrete surfaces by correlating them with results obtained by conventional test methods. Four concrete panels, and standard concrete cylinders, were made from concrete mixtures in which the cement factor and type of aggregate were varied. After curing, th

panels were marked off into 1-ft squares and one face was exposed to a wet sand mat and the other to laboratory air for additional curing. Tests were then made with the hammer on both faces, in accordance with manufacturer's instructions. Cores, beams, and prisms were extracted from the panels and tested for compressive and flexural strength. The investigation indicated that the Schmidt hammer can be used to estimate the strength of concrete provided it is calibrated under the conditions for which it is to be used, and the manufacturer's graphs. From author's summary

1263. Anderson, J. O., and Sanborn, C. F., A machine for high temperature fatigue testing of gas turbine buckets, *Proc. Soc. Exp. Stress Anal.* **15,** 2, 11–20, 1958.

1264. Kal'ner, D. A., Testing cold-drawn wire with a joint to destruction (in Russian), *Zavod. Lab.* **22,** 3, 323–325, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4975.

Properties of Engineering Materials

(See also Revs. 1155, 1156, 1194, 1232, 1238, 1242, 1257, 1259, 1330)

Book—1265. Comings, E. W., High pressure technology, New York, McGraw-Hill Book Co., Inc. (Chemical Engineering Series), 1956, xi + 535 pp. + glossary + index. $11.50.

Book is a treatise on the art and, where practical, the science of chemical operations carried out under pressure conditions ranging from 10 atm to 9000 atm. Often these processes are carried out at high temperatures when the temperatures are considered in light of the imposed pressures.

The book builds on the foundation established by the work of P. W. Bridgeman and to a lesser extent the subsequent work of Harold Tongue and D. W. Newitt. The objective of this book is to provide an integrated discussion of high-pressure technology as it concerns the chemical engineer. It is a rather complete statement of the current status-of-the-art of high-pressure technology.

Contents include sections on chemical processes; metals and metal properties for use in construction of high-pressure systems; safety requirements; stress analysis; experimental techniques; high-pressure equipment; the thermodynamical and transport properties of gases and liquids; chemical-engineering unit operations (heat transfer, flow of fluids, absorption, etc.); chemical equilibrium and chemical reactors. The first eleven chapters treat the fundamental steps in simple systems. The last chapter treats in detail the synthesis of ammonia from hydrogen and nitrogen, this being the first chemical reaction to be carried out at high pressures on an industrial scale. The ammonia synthesis process is presented as an example of the engineering of a high-pressure chemical process, and serves to integrate the principles discussed in the first eleven chapters.

Chapter 2, "Chemical Processes," was prepared by R. Norris Shreve and is an excellent compendium of chemical processes employing high pressures (10–9000 atm) for which a reasonable background in chemistry and chemical processes is necessary. Chapter 3, "Metals," was prepared by H. C. Van Ness. The treatment is limited to steels and steel alloys, tests and testing, machinability, high-temperature properties (creep, corrosion, carbon precipitation in austenitic steels, etc.) gas attack (especially hydrogen) on metals, etc. Other than iron alloys and steel alloys only a small section is devoted to special alloys (the Inconels, Monels, Hastelloys, Stellites, Chromax, Nichromes, etc.), which was somewhat disappointing to the reviewer.

Useful appendices are added on dimensions and units; constants for equations of state; thermodynamic properties of gases, liquids and solids; equipment sizes; limits of flammability of gases and vapors; mercury cleaning techniques; steels and alloys for high-pressure work; problems and questions; and finally a glossary of terms. The last this reviewer found most helpful. Author provides an excellent bibliography.

The information and techniques described in the book will certainly be valuable to researchers and designers in the high-pressure field generally and for this purpose the book probably has no parallel; however, it appears to the reviewer to be less useful as a text than as a reference book.

R. M. Drake, Jr., USA

1266. Cox, D. D., Selecting structural materials for supersonic flight, *Aero. Engng. Rev.* **17,** 1, 28–31, Jan. 1958

1267. Denny, J. P., and Kendall, L. F., Jr., New engineering metals, *Mech. Engng., N. Y.* **80,** 8, 67–71, Aug. 1958.

1268. Farnell, K., Piecemeal yielding of mild steel—Theory applicable to problems involving stress reversal, *Engineering* **185,** 4793, 92–93, Jan. 1958.

1269. Muvdi, B. B., Sachs, G., and Klier, E. P., Design properties of high-strength steels in the presence of stress concentrations, Part I: Dependence of tension and notch-tension properties of high-strength steels on a number of factors, WADC TR 56-395 (PB 121847; ASTIA AD 110637), 17 pp. + 16 tables + 25 figs., Dec. 1956.

In this report are presented the results of tension and notch-tension tests performed on hot rolled sections from commercial, electric furnace heats of 4340, V-Mod. 4330, 98B40, Tricent (Inco), Super Hy-Tuf, Hy-Tuf and Super TM-3 steels. Tension tests were conducted on 0.28-in. diam specimens. An exception was a single test completed on a smooth 0.9-in. diam 4340 steel specimen in order to examine the effect of section size on the tension properties of this steel. Notch-tension tests were performed on 0.3, 0.5 and 0.9-in. diam specimens that were heat treated to strength levels ranging between 180,000 and 300,000 psi approximately. These specimens were provided with notches leading to stress-concentration factors, K, of 3, 5 and 10. In both instances (tension and notch-tension tests), longitudinal and transverse specimens were examined. Furthermore, information from the literature pertaining to the effects of as-processed section size is considered and evaluated.

In general, the tensile strength was found to be independent of the specimen orientation, but to decrease gradually with increase in the specimen size. The ductility of smooth specimens, however, was observed to depend on both specimen orientation and specimen size.

The notch strength decreased with increase in stress concentration, specimen diameter and as-processed section size. It also decreased as the specimen orientation was changed from longitudinal to transverse. These effects were pronounced at high strength levels and diminished, with decrease in the tensile strength, to insignificant values at strength levels below 200,000 psi. From authors' summary

1270. Tatarchuk, G. T., Local Pressure losses in cast-iron cross pipes (in Russian), *Vopr. Otopleniya i Ventilyatsii, Moscow,* 1956, no. 3, 49–83; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4248.

1271. Underwood, E. E., Marsh, L. L., and Manning, G. K., Effect of precipitate particles on creep of aluminum-copper alloys during age hardening, *NACA TN* 4372, 29 pp. + 6 tables + 20 figs., Sept. 1958.

Spherical or platelike precipitates were prepared in aluminum alloys with 1 to 4 weight per cent copper. The effects of controlled sizes and distributions of particles were determined by

creep, tensile, and hardness measurements, by quantitative metallographic evaluation of the particle characteristics, and by x-ray and electron-microscope examinations. The importance of matrix composition in relation to alloy strength is shown. An unusual particle strengthening effect is found beyond a critical spacing of about 50 microns. From authors' summary

1272. **Decker, R. F., and Freeman, J. W., Mechanism of beneficial effects of boron and zirconium on creep-rupture properties of a complex heat-resistant alloy,** *NACA TN* 4286, 25 pp. + 4 tables + 18 figs., Aug. 1958.

The effects of the addition of small amounts of boron and zirconium on creep properties of an alloy containing 55% nickel, 20% chromium, and 15% cobalt, with molybdenum, titanium, and aluminum were studied. These additions improved the creep-rupture properties at 1600 F because of a stabilizing effect on the grain boundaries. These additions prolonged the life to fracture and allowed higher deformations before fracture. A number of optical and electron photomicrographs trace the development of microcracks and matrix changes through the creep process.

From authors' summary

1273. **Berry, B. S., and Nowick, A. S., Internal-friction study of aluminum alloy containing 4 weight percent copper,** *NACA TN* 4225, 55 pp. + 4 tables + 29 figs., Aug. 1958.

A study has been made, by means of low-frequency internal-friction measurements in both torsional and flexural vibration, of aluminum alloy containing 4 weight per cent of copper during aging. Both polycrystalline and single-crystal specimens exhibit an initial internal-friction peak at 173° (for a frequency of 1 cps) after solution treatment and quenching. This peak shows all the characteristics of a Zener relaxation, including strong anisotropy. The precipitation of the phase θ is marked by the appearance of a second peak at 135 C (for frequency of 1 cps) and by a rise in the high-temperature background internal friction. Possible causes of the second peak and the background changes are discussed.

From authors' summary

1274. **Burpee, C. M., Pressure preserved wood for permanent structures,** *Proc. Amer. Soc. Civ. Engrs.* **84**, ST 7 (*J. Struct. Div.*), Pap. 1841, 10 pp., Nov. 1958.

Up-to-date information is presented on the wide experience gained with pressure-treated piles, poles, and timbers. The paper, by the most outstanding authority on this subject matter, is recommended to all architects and structural engineers who wish to be familiar with the advantages of pressure-treated wood.

E. G. Stern, USA

1275. **Wood, L. W., The factor of safety in design of timber structures,** *Proc. Amer. Soc. Civ. Engrs.* **84**, ST 7 (*J. Struct. Div.*), Pap. 1838, 18 pp., Nov. 1958.

The excellent detailed discussion of safety factor is of great value since it promotes the proper use of wood for structural purposes as a result of a better understanding of wood.

The variables involved are evaluated on a statistical basis as multivalued factors in order to reduce the average strength of clear wood to design stresses which give consideration to the actual strength of structural timbers. E. G. Stern, USA

1276. **Luxford, R. F., Light wood trusses,** *U. S. Forest Prod. Lab. Rep.* 2113, 14 pp. + 8 tables + 32 figs., Apr. 1958. (Reprinted in *Proc. Amer. Soc. Civ. Engrs.* **84**, ST 7, (*J. Struct. Div.*), Pap. 1835, 48 pp., Nov. 1958.

Detailed information is presented on the experience gained at the U. S. Forest Products Laboratory in the field of trussed rafters by testing (a) two nailed trussed rafters of "W" design of 24-ft span, (b) twelve nailed or glued trussed rafters of "W" design of 17-ft span, (c) five and three glued trussed rafters of "W" design of 26 and 43-ft span, respectively, (d) three glued trussed rafters of king-post design of 32-ft span, and (e) three glued trussed rafters of box-beam type of 32-ft span. The studies were limited to trussed rafters assembled with plywood gusset plates, resorcinol-resin glue, and common wire nails.

The over-all conclusions, based on the observations made and generally applicable, can be listed as follows: (1) Well-designed and well-constructed nailed trussed rafters of 5 in 12 roof slope provide adequate service. (2) Glued trussed rafters are stiffer than nailed trussed rafters, although the tested nailed trussed rafters were found to be stiffer at design load than required. (3) Glued trussed rafters lose some stiffness and a considerable amount of ultimate load-carrying capacity during cyclic exposure to high and low relative humidity, while nailed trussed rafters are less affected. (4) The use of only such glues is recommended as will perform satisfactorily under adverse conditions.

The presented test results may serve as a basis of comparison when testing trussed rafters assembled with (1) improved fasteners, such as hardened threaded nails, and (2) metal plates of various types, such as inserted, nailed-on, bent-over or toothed metal plates as are commercially used today.

E. G. Stern, USA

1277. **Strode, W., and Dean, D. L., Design, construction and testing of a plywood hyperbolic paraboloid lattice structure,** *Univ. Kansas, Bull. of Engng. and Architecture* no. 41, 19 pp., June 1958.

The investigated 20-ft × 20-ft hyperbolic paraboloid, composed of 12-in. strips of two perpendicular layers of ¼-in. Douglas fir plywood (1780 sq ft) and 6-in. × 6-in. × ¾-in. plywood box-beam edge framing (340 sq ft), was supported for stability by three concrete piers at the bottom corners of the structure.

The glue-nailed structure was designed like a solid shell, giving consideration to the fact that it actually is a lattice. Erected by students in six working days, it was tested after a full-year exposure to rain, snow and winds up to 70 mph by applying uniformly distributed concentrated loads up to 50 psf or single concentrated loads up to 3340 lb. At a 20-psf loading, the observed deflections were considerably smaller than predicted on the basis of the computations made. E. G. Stern, USA

1278. **Doyle, D. V., Performance of structural pole frames under test load,** *U. S. Forest Prod. Lab. Rep.* 2111, 30 pp., June 1958.

Six full-size structural roof frames of 4 in 12 slope, designed for 15-ft spacing in a 30-ft wide pole-frame structure of 12-ft eave height, were tested for their strength and rigidity in resisting symmetrical snow and wind loads. The rafters, built up of three 2-in. × 12-in.'s were tied together near the ridge with a 2-in. × 8-in. × 12-ft collar beam at each side of the rafters and with 24-gage metal straps over the ridge. The rafters were fastened to the 16-ft, 6-in. treated poles with ¾-in. plywood gusset plates. Commercial 0.05-in. × 2-in. steel strapping was used to tie together the opposite rafter heels.

Designed for a snow load of 20 psf and a wind uplift load of 22.5 psf (77 mph), the structure, loaded at the quarter points, supported an average snow test load, minus dead load, of 43 psf and an average uplift test load, plus dead load, of 31 psf. The various types of failures indicated a well-balanced design.

E. G. Stern, USA

1279. **Stern, E. G., Nailing of plywood sheathing with "hi-load" nails,** *Virginia Polytechnic Inst., Wood Res. Lab. Bull.* 35, 16 pp., May 1958.

Plywood sheathing can be applied more effectively and more efficiently if, in the nailing, the traditionally used 6d, 8d, and 10d common wire nails are replaced by properly threaded nails of shorter length and extra large shank diameter. Test data are

presented to provide information on the effectiveness of these improved nails. From author's summary

1280. McLaren, A. S., and MacInnes, I., The influence on the stress distribution in an adhesive lap joint of bending of the adhering sheets, *Brit. J. Appl. Phys.* **9,** 2, 72–77, Feb. 1958.

The mathematical analysis of Goland and Reissner of the effect of deformation due to load is examined photoelastically and extended to cover a wider range of such deformations. It is shown that introduction of a bending moment in the sheets opposite to that occurring in the conventional joint can produce a stress distribution on the glue line free from high normal stresses and fairly uniform in shear. A modified design of lap joint to ensure this is proposed.

From authors' summary by J. L. Lubkin, USA

1281. Danielsson, U., and Wastesson, A., The frost resistance of cement paste as influenced by surface-active agents, *Proc. Swed. Cem. Concr. Res. Inst., Roy. Inst. Technol. Stockholm* no. 30, 38 pp., 1958.

The effect of five different surface-active agents on the frost resistance of cement pastes of varying water-cement ratios has been investigated. Results indicate that the frost resistance is mainly determined by the volume and size-distribution of the air-filled pores in the pastes, while chemical effects are of minor importance.

A theory—the theory of the frost-protected volume ratio—is advanced to explain frost damage, based upon the same fundamental assumptions as the hydraulic pressure theory put forward by T. C. Powers. Authors' theory takes the actual size-distribution of the pores into account, instead of assuming them to be of the same size. The frost resistance is expressed in terms of the frost-protected volume per unit volume of paste, v_{pr}, which is approximately:

$$v_{pr} = A(1 + Ka),$$

where A is the total air content per unit volume of paste, a the mean specific surface area of the pores, and K is a coefficient of dimension length which depends on the water-cement ratio and age of the paste, the freezing conditions, and other factors. This formula represents the first two terms of a series and has been found to give a fair estimate of frost resistance.

It follows that admixtures which give small and well-separated pores are preferable but, because of their effect on the workability, other admixtures may be of comparable merit, due to the possibility they offer of decreasing the water-cement ratio, and thus improving the frost resistance. From authors' summary

1282. Nykanen, A., and Pihlajavaara, S., The hardening of concrete under winter concreting conditions (in English), State Inst. Tech. Res., Finland, Publication 35, 160 pp., 1958.

1283. Lux, J. H., Plastics in the space age, *J. Franklin Inst.* **266,** 1, 21–26, July 1958.

1284. McSweeney, E. E., and Heiligmann, R. G., Plastics engineering 1956–1957—A review of developments, *Mech. Engng., N. Y.* **80,** 4, 57–60, Apr. 1958.

1285. Platt, M. M., Klein, W. G., and Hamburger, W. J., Mechanics of elastic performance of textile materials, XIII. Torque development in yarn systems: singles yarn, *Text. Res. J.* **28,** 1, 1–14, Jan. 1958.

This paper is the first of a series which will deal with torque in textile systems. It is concerned principally with the analysis of torque developed in twisted singles yarns as created by (a) fiber bending, (b) fiber torsion, and (c) bending and torsion in combination. Equations are developed, using elastic theory, relating singles yarn torque to fiber elastic properties, fiber geometry, and singles yarn structure. Extension and application of the theory to torque in higher-order textile structure, e.g., plied yarns and fabrics, will appear in subsequent publications.

From authors' summary

1286. Hartman, A., The effect of the relative humidity of the air during fabrication on the mechanical properties of glass fabric reinforced plastics (in English), Nat. Lucht Lab. Amsterdam Rap. NLL-TN M. 2045, 14 pp. + 3 tables + 6 figs., Jan. 1958.

For the applied type of glass fabric and polyester-resin the investigation showed that a combination of a high relative humidity of the air during fabrication and a curing temperature above 100C increases the probability of porosity. With curing at room temperature the relative humidity of the air during fabrication has no effect on the static mechanical properties and the structure of glass reinforced plastics, even if the postcure is executed at a temperature > 100C. The decrease in mechanical properties of the specimens by immersion in water of 25C for 30 days was much more severe for the compressive and flexural strength than for the tensile strength, but was independent of the relative humidity of the air during fabrication.

From author's summary

Structures: Simple

(See also Revs. 1190, 1196, 1197, 1198, 1203, 1219, 1243, 1274, 1275, 1276, 1277, 1278, 1279, 1282, 1295, 1615)

Book—1287. Michalos, J., Theory of structural analysis and design, New York, Ronald Press Co., 1958, vii + 552 pp. $12.

The title of this book is somewhat misleading since the book actually is concerned with the analysis of statically indeterminate structures which occur in civil engineering. Structural forms which are treated include the usual continuous beams and frames, statically indeterminate trusses, arches and rings. In addition to the treatment of plane problems, two chapters are devoted to out-of-plane loading of frames and curved members, to elementary space structures, and to an approximate method for the analysis of skewed arches essentially due to Rathbun.

In common with many contemporary American books in this area, emphasis is on the moment-distribution method. However, the Maxwell-Mohr method, the column analogy, Williot diagrams, and elastic weights also seem to be adequately covered. Because of their importance and wide use in the analysis of bridges and other structures for necessarily movable loads, considerable space is devoted to the drawing of influence lines. The book also gives an approximate method, due to this reviewer [AMR **6** (1953), Rev. 3712], for handling gusseted members under combined axial load and bending in such applications as the analysis of secondary stresses in bridge trusses. The general failure of the author to mention antecedents and to provide specific references might be disturbing to informed readers. J. Goldberg, USA

1288. Sawyer, H. A., Jr., An elastic criterion for plastic design, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 2 (*J. Struct. Div.*), Pap. 1566, 17 pp., Mar. 1958.

When an indeterminate frame or beam is loaded beyond the elastic limit, a redistribution of moments occurs which provides the indeterminate structure with a reserve of strength with respect to collapse that is not available to a statically determinate structure. Current design specifications for steel building frames and beams fail to take advantage of the resulting greater collapse strength of an indeterminate structure since design load factors are based on the elastic limit. Author proposes design load

factors based on mechanism collapse for use in plastic design and discusses the effect of deformational limitations, local instability and repeated wind loading.

After an extensive discussion, author concludes that the probability of a fatigue failure due to repeated alternating plastic strains induced by wind loading is negligible. Author also demonstrates that specification of a minimum elastic limit load factor does not eliminate the possibility of excessive deformation. However, premature failure due to local buckling may be prevented by using suggested values for the elastic limit load factor in plastic design. W. K. Rey, USA

1289. Posner, H., Moments in beams by the method of partial moments, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 2 (*J. Struct. Div.*), Pap. 1567, 34 pp., Mar. 1958.

Since the loading on an individual span of a continuous beam produces moments (referred to as partial moments) at all points of support over which the beam is continuous or at which restraint exists, the total moment at each support of a continuous beam loaded on more than one span may be determined as the algebraic sum of the partial moments produced at these supports by the separate loadings on each span. By application of this principle in conjunction with the Theorem of Three Moments, author has developed a series of algebraic expressions for use in determining support moments in restrained or continuous beams subjected to uniformly distributed or concentrated loads. Two illustrative examples are solved both analytically and graphically.

Although this method is in general not applicable to frames, it may be a time-saving tool for continuous beams having more than four spans or when several loading conditions must be investigated for the same beam. W. K. Rey, USA

1290. Broms, B., and Viest, I. M., Ultimate strength analysis of long restrained reinforced concrete columns, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 3 (*J. Struct. Div.*), Pap. 1635, 31 pp., May 1958.

A method is presented for the analysis of the ultimate strength of long restrained reinforced-concrete columns. The analysis of concentrically loaded columns is based on the tangent modulus theory, and that for eccentrically loaded columns is based on the Karman theory. The results obtained are presented in dimensionless graphs, but test data are not available, which is especially important because the method involves two assumptions in addition to those used in the theory of hinged columns.

The effects of these additional assumptions should be investigated by experimental means. M. M. Stanisic, USA

1291. Higgins, T. R., Plastic design in steel—a progress report, *J. Boston Soc. Civ. Engrs.* **45,** 3, 207–226, July 1958.

Book—1292. Evans, R. H., and Bennett, E. W., Pre-stressed concrete—theory and design, New York, John Wiley and Sons, Inc., 1958, xv + 294 pp. **$10.**

Shorn of much purely descriptive material, book presents concise treatment of basic principles which effectively fulfills didactic needs of students and practicing engineers unfamiliar with field. Planned with considerable elegance, part I exposes fundamentals applicable to all structural types; part II applies essentials to design of simply supported beams with design-office procedure in mind; part III provides introduction to specialized applications, including composite construction, indeterminate structures, circular structures, domes and shells.

Distinctive advantages of prestressed over reinforced-concrete construction are appropriately emphasized.

Representative sampling of literature, appended to each chapter, offers good starting point for more detailed study of particular topics. Numerous examples with answers aid understanding.

Part III on special structure, comprising one third of book, should be helpful in furnishing some insight into vast potential of possible applications in structural engineering despite the fact that this portion could be significantly expanded.

A. W. Coutris, USA

1293. Pelikan, J., Theory of highly economical reinforced beams, (in Hungarian), *Acta Techn. Hung. Budapest* **17,** 39–56, 1957.

This paper and two previous papers of the author [Proc., Scientific Meeting of Techn. Univ. Budapest, 1955, 345–350 (in Hungarian), and *Acta Techn. Hung. Budapest* **15,** 373–380, 1956] dealt with the limit design of continuous reinforced-concrete beams. The spans, the load and the concrete cross section are given. If z is the depth, the problem consists of finding the tensile reinforcement. To solve this problem, author introduces the postulate

$$\int (|M|/z)\,ds = \text{minimum} \qquad [\bullet]$$

Because $|M|/z$ is practically proportional to the tensile reinforcement, author's postulate leads to a highly economical reinforcement.

In a recent paper [*Építöipari és Közlekedéstud. Közl.* **1,** 3/4, 275–284, 1958 (in Hungarian)] author treats the same problem and attempts to show that the classical minimizing principle of Castigliano also results in requirement [•]. An essential point of this reasoning is the following: it will be assumed that the flexural rigidity may be computed from the compressed part of the concrete area and from the reinforcement area.

J. Barta, Hungary

1294. Abeles, P. W., Prestressed concrete pipes and circular tanks. Parts I–IX, *Civ. Engng., Lond.* **50:** 593, 1235–1238, Nov. 1955; 594, 1375–1378, Dec. 1955; **51:** 595, 83–84, Jan. 1956; 596, 203–206, Feb. 1956; 597, 319–322, Mar. 1956; 599, 552–554, May 1956; 600, 671–672, June 1956; 602, 895–896, Aug. 1956; 603, 1008–1010, Sept. 1956.

After a short historic review of the development of prestressed pipes and tanks, author discusses four principal types of prestressed pipe, analyzing stresses due to internal pressure and circumferential prestress and defining factors of safety. He then describes in some detail the best-known systems for fabricating prestressed pipe. The last five articles of the series are dedicated to circular prestressed tanks, showing different methods of construction and application of prestress. Special attention is given to factors influencing stress distribution, with tables of coefficients to calculate bending moments and ring forces considering different kinds of bases. Papers give a concise resume of the subject with a profusion of illustrative sketches and photographs; a bibliography of thirty-two listed titles can serve as guide for more detailed study. E. Rathgeb, Argentina

1295. Galletly, G. D., and Chilton, E. G., Prestressed cylinders with non-metallic linings subject to internal pressure and temperature, Shell Development Co. Research Center, P-639, 17 pp. + 3 figs.

Vessels for highly corrosive reactions at high pressures and temperature can be built with metallic shells and nonmetallic linings. For optimum design they are prestressed so that the liner does not crack and will not separate from the shell during operation. A method is given in the paper whereby the required wall thicknesses and prestress may be determined for the cylindrical portion of a vessel open at both ends and without openings or attachments. The method of Matz, presently in use for the

design of such vessels in Germany, is reviewed. An example illustrates the use of this method and the differences between the two methods. M. Holt, USA

1296. Hoffman, G. A., Poisson's ratio for honeycomb sandwich cores, *J. Aero/Space Sci.* **25,** 8, 534-535 (Readers' Forum), Aug. 1958.

1297. Chang, C. C., and Ebcioglu, I. K., Elastic instability of rectangular sandwich panel of orthotropic core with different face thicknesses and materials, Univ. of Minn., Inst. of Technol., Composite Structure Rep. no. 1, AFOSR TN 58-221, (ASTIA AD 154 122), 54 pp., Mar. 1958.

A method is derived to calculate the elastic stability of rectangular panels of orthotropic core and isotropic faces of different materials and unequal thicknesses, simply supported and loaded with edge compression. The differential equations are derived from energy integral by means of variational method. The effect of different face temperatures on the collapsing load is considered. A comparison with current, different methods is given. Illustrative examples are shown. T. H. Lin, USA

Book—1298. Kani, G., Analysis of multistory frames, fifth edition, New York, Frederick Ungar Publishing Co., 1957, 113 pp. $4.50.

This relatively short book presents what has become known as the Kani method of analysis of rigid frames. Procedure is iterative and includes both the effects of joint rotation and joint translation. Use of the method in constructing influence lines is explained, as is its application to problems of bending of frames containing elements with variable rigidity. The method is simple in application and clearly presented, with sufficient number of examples.

Reviewer considers the Kani method, and the book, a valuable addition to the literature of the subject. It is noted that a proof of convergence of the procedure is not given; reviewer believes this does not detract from the value of a book obviously directed to structural engineers. S. J. Medwadowski, USA

1299. Haemmerling, A. V., The resistance of columns in steel-frame buildings (in Russian), "The calculation of three-dimensional structures," no. 3, Moscow, Gos. Izd-vo Lit. po Str-vu i Arkhitekture, 1955, 55-83; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7103.

Author determines displacements and stresses occurring in columns as a consequence of horizontal, constrained displacements of the joints for whatever reason. The columns (one- and two-storey) are considered isolated from their adjacent elements, e.g., facings and horizontal members, the influence of the last-named being partly considered by the end moments and transverse forces; the intermediate moment in a two-storey column is not considered.

Analysis of the solution shows that in the case of very many single-storey columns (as well as first-storey columns gripped at the bottom) the danger of exhaustion of the carrying capacity owing to the formation of plastic hinges in the intermediate state is excluded.

The influence of elastic-plastic deformations on the carrying capacity of a rod (column) is discussed in application to an *I* cross section with supplementary ribs. Results are communicated of calculations made on the basis of a series of assumptions, the most important of which are the assumption of a two-dimensional cross section and omission of deformations of the rod out of the plane of the wall. Experiments made in the USSR are described, (Akad. Nauk USSR in 1940; Mosk. Inst. Communist Economy in 1946; CNIPS in 1951), and the results analyzed.

I. K. Snitko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1300. Shapovalov, S. M., Calculation of frame constructions by the method of momentary focal ordinates (in Russian), *Nauch. Zap. L'vovsk. Politekhn. In-ta* no. 29, 22-49, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6013.

1301. Klechanovsky, A. A., The calculation of steel single-storey trusses with stepped struts by the method of focal momentum ratios (in Russian), *Nauch. Trudi Novocherkassk. Politekhn. In-ta* **29,** 43, 25-42, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7158.

A calculation for unconstrained truss frames with stepped struts is made by the method of successively balancing moments, without introducing additional constraints against linear displacements.

The balancing of the moments is reduced to distributing the moments between the real and imaginary joints of the truss. An example of a truss with a triangular strut section is given.

N. K. Snitko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1302. Rzhaninyn, A. R., Representation of uniform isotropic elastic body in the form of an articulated rod system (in Russian), Issledovaniya po Vopros. Stroit. Mekhan. i Teorii Plastichnosti, Moscow, 1956, 84-96; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5852.

An examination was made of a three-dimensional cubically shaped grid of rods with supplementary connections along the diagonals of the grains in one case, and along the diagonals of the grains and the diagonals of the cube—in the other. With the determined correlations between the rod sections the grid would behave as an elastic isotropic body. Calculations were made for the elastic constants of such a grid in relation to the rod sections. Poisson's ratio in this case was always equal to one quarter. Equations of differences were constructed for the rod grid, modelling an elastic body in a plane condition of tension or deformation.

Yu. N. Rabotnov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1303. Diwan, A. F., Analysis of open-spandrel arches, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 2 (*J. Struct. Div.*), Pap. 1564, 36 pp., Mar. 1958.

Paper presents a mathematical solution for the open-spandrel arch as a monolithic structure assuming full continuity between the arch rib, the spandrel columns, and the deck. The solution is based on the principle of balancing the panel moments by imposing therein a special type of panel distortion which produces moments of a known pattern in the chords of the deformed panel only, and nowhere else in the open-spandrel arch. This makes it now possible to study mathematically the interaction between the deck, the spandrel columns and the arch rib, as well as the effect of introducing expansion joints in the deck, and thus make use of the so-called deck participation in the design of this type of arch bridge. From author's summary

1304. Majer, J., Contribution to the calculation of inclination of weakly loaded rigid foundations (in German), *Bautechnik* **35,** 4, 129-133, Apr. 1958.

Formulas for inclination of rigid, square and rectangular footings are developed, assuming soil homogeneous, elastic and isotropic but accounting for stratification. Case of gradually increasing vertical eccentric load is solved by analogy with standard solutions for circular and strip loading. Case where full vertical load is subsequently displaced, and allowing for the large difference in compressibility and expansion of soil, is solved for normally consolidated conditions by the use of (the reviewer believes) questionable assumptions and approximations.

G. A. Leonards, USA

1305. Vandepitte, D., Bearing load of pile foundations. Parts I, II, (in French), *Ann. Trav. Publics Belg.* no. 1, 7-44; no. 2, 5-47, 1957.

In the first part of paper author gives a general survey of the methods available for computing the repartition of pile loads in a plane piled foundation. He states clearly the basic assumptions of the different procedures, and presents in detail the method originated from Nökkentved and its variations as well. For the method using the center of rotation author proposes a new graphical solution which—through good arrangement of the coördinate axes—involves considerable simplification. He works out this method also for the case of piles with fixed heads. These methods, however, as author demonstrates in chap. III, do not determine the true bearing capacity of the piled foundations; it may be proved, as shown in numerical examples, that a given piled foundation might reach a favorable condition through the omitting of a pile.

Therefore, chap. IV fixes the basic principles of a new method, stating that a given foundation does not fail by reaching the yield value of some piles; in this case, the pile forces redistribute themselves. Taking the pile-loading diagram as a broken line, composed of a slanting and a vertical portion (the former taken valid for loading and pulling as well), author develops a method with successive approximation, using the method of Nökkentwed with iteration. The yield values of the piles can be taken into consideration. He investigates, then, the limiting states of a piled foundation which are statically and geometrically possible. Chapter V proves that there is one and only one limiting state which corresponds to both requirements; the resulting force of it gives the bearing capacity of the foundation. Chapter VI presents ways of practical application and numerical examples. The latter, however, run through the whole paper, serving sometimes to prove statements.

Reviewer believes that the presented investigation of a piled foundation represents a step from the purely statical and geometrical procedures toward reality; but the true deformations of the soil and the effect of superposition of stresses cannot be considered; there is a need for a such solution.

A. Kezdi, Hungary

1306. Mednikov, I. A., The calculation of cement concrete road slabs for destructive loading (in Russian), *Trudl Mosk. Avtomob.-dor. In-ta* no. 16, 66-78, 1955; *Ref. Zb. Mekh.* no. 6, 1957, Rev. 7095.

A theoretical analysis of the load-carrying capacity of a cement-concrete slab of unlimited extent resting on a continuous foundation and uniformly loaded over the area of a circle of small radius. The solution is founded on a number of assumptions concerning the shape of the surface of the annular crack, the law of distribution of the principal tensile stresses over the thickness of the slab, and the conditions for the mechanical resistance of the materials. For the determination of the destructive load, the conditions are set up for the limiting equilibrium of the part of the slab within the circular crack. Calculation formulas and numerical examples are given.

The application of the method of limiting equilibrium is contradictory to accepted assumptions concerning the brittle character of fracture of the material working in tension.

A. R. Rzhanitsyn

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1307. Clough, R. W., Use of modern computers in structural analysis, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 3 (*J. Struct. Div.*), Pap. 1636, 21 pp., May 1958.

Structures: Composite

(See Revs. 1266, 1327, 1645)

Machine Elements and Machine Design

(See also Revs. 1119, 1126, 1184, 1239, 1254, 1302)

Book—1308. Matousek, R., Machine design procedure [Konstruktionslehre des allgemeinen Maschinenbaues], Berlin, Springer-Verlag, 1957, vii + 211 pp. DM 19.80.

Book treats design tactics in general mechanical design and is addressed primarily to young M. E. designers. First the activities of the designer are determined and then his main qualifications mentioned: Mental and character qualities, special knowledge. Further on, many points influencing design are given and some steps for design-office organization proposed. Author, in main part of the book, suggests a methodical procedure for designers to follow: Careful examination of the problem and requirements set by the customer's drawing after several trials of one principal sketch; selection of the appropriate materials; selection of the production processes; form design with consideration of important influencing factors such as mechanical strength, materials, manufacturing processes, available space, size, weight, standardization, appearance, repairs, etc.; cost.

Numerous figures, tables, diagrams and exercises with solutions are included. Book is a valuable aid for young people choosing the design career, but some lack of general scope is noted due to too many details.

N. Theophanopoulos, Greece

Book—1309. Hohenberg, F., Descriptive geometry for engineers [Konstruktive Geometrie für Techniker], Wien, Springer-Verlag, 1956, vii + 272 pp. $5.25.

Book is divided into three parts:

In the first part, author deals with the basic methods of descriptive geometry, as horizontal and vertical projections, axonometry, perspective geometry, reconstructions, etc. In the second part is the construction of curves and surfaces of technical importance, the application of measuring number method of empirical curves and surfaces, etc. The third part is a detailed investigation of drives, gears and other products of mechanical engineering, by the method of kinematical geometry.

The book is written for practical men on a scientific level. The great number of examples taken from everyday practice, the easily understood text, and clear figures make this book very valuable.

A. L. Simon, USA

1310. Yokota, A., On gears with cylindrical surfaces, *Bull. JSME* **1,** 1, 75-79, Jan. 1958.

Paper deals with gears having cylindrical surfaces and constant angular velocity ratio. After brief discussion of skew and spiral gears, author reviews the case of line contact between gears having cylindrical surfaces, then treats the case of point contact between these surfaces. For the latter case, given on profile, the equation for the radius of curvature of the mating surface is developed. Possibility of interference between these gear surfaces is considered. Equations for the profiles of the two mating surfaces are developed and expressed in polar form.

A. G. Sharp, USA

1311. Blottner, F. G., Effect of loads on the spring constant of a particular type of flexure, *J. Aero. Sci.* **25,** 4, 272-273 (Readers' Forum), Apr. 1958.

1312. Schuette, E. H., How to calculate stresses in press-fit bushings, *Prod. Engng.* **29,** 35, 51-53, Sept. 1958.

1313. Schilhansl, M. J., The pin, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-23, 9 pp.

An analytical approach has been made in the paper to understand the complicated problem of pin design. It has been shown that the traditional way of considering only the static shear load, as in the design of conventional pin elements for knuckle joint assembly, is not enough for the several types of pins that have been developed to meet a wide range of varying application and assembly requirements.

In addition to static load, the factors influencing the selection and application for solution of specific design problems are reduction in strength by the additional bending load imposed by shearing action, shock and vibration due to service conditions, clamping force, resilient action of the hollow-cylinder walls, etc. The effects of interference fit on strength and the behavior of the pin under external loads, both static and dynamic, have been analyzed in the cases of dowel pin, slotted tubular pin, and spirally coiled pin. It has been shown that with standard practice and same conditions of fit and size, the spirally coiled pin has an advantage over the other two. B. M. Belgaumkar, India

1314. Austin, L. H., How to design conveyor rolls for drive or drag, *Prod. Engng.* **29,** 38, 78-79, Sept. 1958.

1315. Ulukan, L., Forces and their distributions in toothed chains (in German), *Bul. Istanbul tekn. Univ.* **10,** 3, 7-22, 1957.

1316. Gotziridze, G. D., Calculation of a single stage differential drive (in Russian), *Trudi Gruz. Politekhn. In-ta* no. 34, 11-18, 1954; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5226.

Three cases are examined of the calculation for a closed differential mechanism, in which is included a single-stage variator: (1) With the given single-stage variator a determination is made of the number of teeth in the differential part of the mechanism in accordance with the given range of control of the velocity of the known link. (2) With the given single-stage variator and the given differential mechanism a determination is made, in the given range of control of the velocity of the known link, of the number of teeth in the constant transmissions to the leading links of the differential mechanism. (3) With the given differential mechanism and in accordance with the given range of control of the velocity of the known link the ranges of control of the single-stage variator are determined. N. I. Levitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—1317. Beyer, R., Kinematic and mechanism practice—Handbook and exercise book for the analysis of plane mechanisms [Kinematisch-getriebeanalytisches Praktikum; Hand- und Ubungsbuch zur Analyse ebener getriebe für den Konstrukteur, die Vorlesung und das Selbststudium], Berlin, Springer-Verlag, 1958, vii + 172 pp. DM 28.50.

This general handbook sets forth the principles of the analysis of plane mechanisms. As is customary in German practice, considerable space has been devoted to the study of generated curves and their properties. The analyses are not limited to the slider-crank linkages.

The first section deals with kinematic inversions, analysis of point motions, relative motions, and to the properties of the paths of instant centers. The second portion deals with acceleration analyses. Ample use is made of graphical as well as numerical methods of investigation. Vector notation is used throughout. Wedge and screw mechanisms are presented. Forty exercises are provided as ample material for practice.

A concise and practical reference for the worker in the fundamentals of this field. C. E. Balleisen, USA

1318. Glushchenko, I. P., Dynamic elements of a single two-mass system with a nonlinear link (in Russian), *Dokladi L'vovsk. Politekhn. In-ta* **1,** 2, 58-63, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5193.

The movement is investigated of two masses, joined together by a flexible, heavy inextensible thread, under the influence of a constantly moving force applied to the first mass. The obtained system of differential equations of the second order is linearized on the assumption that the masses,together with the forward motion, effect small almost linear oscillations near the position of equilibrium. The solution obtained makes it possible to investigate the magnitude of the periodically changing forces with which the second mass reacts on the first. E. N. Miroslavlev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1319. Tyshkevich, V. A., Method of zones of relationship of mechanisms and its application when studying the properties of hinged four-link components (in Russian), *Trudi Seminara po Teorii Mashin i Mekhanizmov In-ta Mashinoved. Akad. Nauk SSSR* **16,** 62, 11-25, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5225.

The mechanism is presented in the form of an imaginary point in an n-dimensional system of coordinates, on whose axes the relative dimensions of the links are plotted. Then the geometric zone of the existence of mechanisms with identical kinematic arrangements is established: points of the mechanism, possessing similar kinematic properties, are disposed on the determined lines, surfaces and in regions, named zones of relationship. The proposed method is suitable for the designing of mechanisms with (the) lower pairs according to the law of motion of the known link. V. N. Geminov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1320. Belitzkii, V. Ya., Designing of crank-balance arm mechanisms (in Russian), *Trudi Odessk. Tekhnol. In-ta* **7,** 33-41, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5227.

1321. Kutukov, A. A., The appearance of impacts in cross mechanisms (in Russian), *Nauch. Tr. Novocherkas. Politekhn. In-ta* **26,** 402-412, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5231.

A method is given for the determination of the initial acceleration of the known part of the cross mechanism when taking into account the impact of the spindle on the slot of the known part. In order to determine the force of impact an examination is carried out of the mutual impact of two bodies of known mass, with a spring of known flexibility inserted between them. The velocity of approach of the two bodies coming into collision is calculated with due regard to the deviation of the actual dimensions from the normal within the limits of tolerance of the third class. An experimental check on a special experimental appliance resulted in a close concordance of the actual values for the angular acceleration of the known part of the mechanism with the values calculated according to the proposed method.

N. I. Levitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Fastening and Joining Methods

(See also Revs. 1247, 1312)

1322. Park, F. R., Magnetic-force welding, *Prod. Engng.* **29,** 38, 82-85, Sept. 1958.

1323. Wayman, C. M., and Stout, R. D., A study of factors affecting the strength and ductility of weld metal, *Welding J.* **37**, 5, (Research Suppl.), 193-s–200-s, May 1958.

1324. Lashko, N. F., Lashko-Avakian, S. V., Technological strength of welded joints in the process of crystallization (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 103–114, Jan. 1957.

1325. Moisseev, I. A., The static and vibration strength of Bessemer steel welds (in Russian), *Trudi Vses. N.-i. In-ta Transp. Str-va* no. 20, 217–244, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7315.

Mechanical tests were made on weld joints in three types of steel: (acid) Bessemer, made in 1952; improved (acid) Bessemer, made in 1953; and rimmed open-hearth,—in sheets between 10 and 40 mm thick. The tests were made on butt and double-strap butt joints with longitudinal and transverse seams. The experiments were made at room temperatures, and below, under static and alternating load.

The tests on joints in Bessemer steel of 1952 production showed that, under static load, failure at room and lower temperatures took place at identical values of the ultimate strength, but at low temperatures the fracture was often brittle. The ratio of yield point to ultimate strength markedly increased at low temperatures, particularly in the case of thick sheets and joints incorporating stress concentrations.

The tests on joints in improved Bessemer steel of 1953 production and rimmed open-hearth steel showed that at low temperatures the ratio of yield to ultimate strength increases to a far smaller degree than in the case of open-hearth steels.

Fatigue tests with a cyclic characteristic of 0.2 showed that welded joints of improved Bessemer steel had the same fatigue limit as weld joints in rimmed open-hearth steel.

G. A. Nikolaev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1326. Brodskii, A. Ya., A method for testing welded nodes in the reinforcement of ferro-concrete structures (in Russian), *Zavod. Lab.* **22**, 10, 1220–1224, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6101.

1327. Kuz'minov, S. A., Calculation method for the determination of general deformation of structural parts due to welding (in Russian), *Vestnik Mash.* no. 9, 70–75, 1954; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6152.

Author has deepened and developed the method of determination, acceptable to engineers, of the residual deformations of constructions when welded, known in the literature under the name of the method of shrinkage forces. The deformation is determined from the conditions of thermal loading calculated by means and on the basis of the thermal processes of welding. It was shown that the influence of transverse seams was more significant than that of the longitudinal as regards residual deformations in welded constructions. An example is given for the calculation of residual deformations of a double-T beam due to the welding on of ribs and seams on its flange; some ideas are put forward to combat the formation of residual deformations.

G. A. Nikolaev
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1328. Jones, J. B., and Meyer, Florence R., Ultrasonic welding of structural aluminum alloys, *Welding J.* **37**, 3, 81s–92s, Mar. 1958.

1329. Black, J. M., and Blomquist, R. F., Relationship of metal surfaces to heat-aging properties of adhesives bonds, *NACA TN* 4287, 19 pp. + 4 tables + 6 figs., Sept. 1958.

A study was made to determine the probable causes of deterioration of each of several adhesives in bonds to stainless steel at temperatures from 400 to 550 F. Preliminary studies of aluminum surfaces on which ions of metals used in stainless steel were introduced showed that iron was probably catalyzing a thermal deterioration of the adhesive. The resistance of FPL-878 adhesive to thermal deterioration at 550 F on steel was improved significantly by treating the steel surface to be bonded with either zinc or cerium naphthenate and firing at 1200 F. The addition of manganese dioxide to the adhesive also increased its resistance to thermal deterioration. A study of the thermal-aging properties of five different chemical types of adhesives on stainless steel and aluminum revealed that a phenolnitrile rubber adhesive was superior to a phenol-epoxy adhesive on steel, but this order was reversed on aluminum. These and other observations indicated probable specific relationships among the chemical structure of the adhesive, the metal adherend, and the resultant thermal stability of bonds after aging at high temperatures.

From authors' summary

1330. Humke, R. K., Sandwich panel adhesives, *Prod. Engng.* **29**, 21, 56–60, May 1958.

Rheology

1331. Oldroyd, J. G., Non-Newtonian effects in steady motion of some idealized elastico-viscous liquids, *Proc. Roy. Soc. Lond.* (*A*) **245**, 1241, 278–297, June 1958.

In a way similar to that used by the reviewer in a previous publication [Yoh-Han Pao, *J. appl. Phys.* **28**, 591–598, 1957], the present author has taken simple rheological equations of state suitable for linear (small strain) viscoelastic behavior and has generalized them to represent viscoelastic fluid flow behavior. The generalization consists in essence of replacing the time derivative by the material derivative following the typical fluid element, taking into account the linear and angular motion of the element. This generalization is sufficient to bring about a non-Newtonian viscosity.

In a sense the present work is more general than the simple theory of the reviewer, since normal stress effects can also be accommodated. On the other hand, the reviewer worked with a viscoelastic spectrum rather than five arbitrary physical constants and there is consequently more latitude in representing actual data.

Y.-H. Pao, USA

1332. Dintenfass, L., A new rheological classification for pigment suspensions in polymer solution, *J. Appl. Chem.* **8**, 6, 349–351, June 1958.

A new rheological classification is proposed for suspensions of pigment in Newtonian and non-Newtonian vehicles.

From author's summary

Hydraulics

(See also Revs. 1331, 1435, 1463, 1563, 1589, 1604, 1605)

Book—1333. Troskolanski, A. T., Hydraulics [Hydraulika], Warsaw, Panstwowe Wydawnictwa Techniczne, 1958, 399 pp.

Author of the three-volume "Hydromechanika Techniczna," 1951–1957, [AMR **9**, (1956), Rev. 3633 and AMR **11** (1958), Rev. 502] has published an elementary textbook for higher technical

schools, almost entirely eliminating calculus. With this exception, this book corresponds closely to our standard textbooks; even exemplary problems are discussed at the end of every chapter. Distribution of material follows classical treatises: hydrostatics, dynamics of ideal fluid, dynamics of real liquids, hydraulics—flow through orifices, weirs, open channels, pipelines, losses, hydrodynamic pressure and reaction, underground water motion. Auxiliary tables and conversion factors for English system of units close this well-written and perfectly edited book, one of the best in Europe for technical schools.

S. Kolupaila, USA

1334. Newman, S. B., and Lee, W. M., Surface tension measurements with a strain-gauge-type testing machine, *Rev. Sci. Instrum.* **29,** 9, 785–786, Sept. 1958.

1335. d'Hieres, G. C., On the existence of a velocity potential for a perfect rippling liquid surface (in French), *C. R. Acad. Sci., Paris* **246,** 12, 1803–1806, Mar. 1958.

1336. Vasil'ev, O. F., Some problems on the mechanics of spiral and circulating streams (flows), *Sb. Tr. Mosk. Inzh.-Stroit. In-ta* no. 9, 65–99, 1955; *Ref. Zh. Mekh.* no. 1, 1957, Rev. 426.

1337. Schroder, R., Velocity distribution and energy conversion in fully turbulent waterflow (in German), *Wasserwirtschaft* **48,** 10, 268–274, July 1958.

Author refers to the dispersion factor ϵ defined by Jaeger [Engineering Fluid Mechanics, p. 115] as $\epsilon = (-2g/Av_m^3) \int \delta H \cdot dA$, where A = cross section of flow, $v_m = Q/A$ average velocity, and δH = energy H_z of individual stream tube z minus average energy H_A in cross section $A (\delta H = H_z - H_A)$. Jaeger showed ϵ to depend only on uneven velocity distribution when stream tubes are not curved.

In a recent thesis [Berlin Technical University, 1957] author showed that friction losses λ in a discontinuous highly turbulent flow depend only on ϵ. If J = energy line gradient, he shows that $J = c\epsilon$, c = constant. Author applies this remark to pipes. He analyses 13 velocity distribution curves published by Nikuradse on smooth pipes and 11 curves on rough pipes and shows the linear relations $\epsilon \simeq 2\lambda$ and $\epsilon \simeq 1.5\lambda$ to be valid. An attempt to analyze these relations more closely is made.

Reviewer thinks the research work carried out by author to be of fundamental importance as showing that the losses in a pipe depend on the velocity distribution and energy dispersion in the pipe cross section.

C. Jaeger, England

1338. Temnov, V. K., Hydraulic friction in short pressurized water conduits in the light of the quadratic law of resistance (in Russian), *Trudl Mosk. Energ. In-ta* no. 19, 135–149, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5535.

In order to obtain calculating formulas for the coefficients of resistance along the length of short rough pipes, working in the quadratic zone of resistance, use is made of the so-called Karman correlation for the union of the alteration of the quality of motion in the turbulent boundary layer with the pressure forces and turbulent friction, the logarithmic law of the distribution of velocities in the boundary layer and the equation for the change of speed in the center of the stream. The solution of the closed system of equations brings one to the differential equation, calculated out in relation to the thickness of the boundary layer. By adopting approximate methods of graphic and numerical integration for the solution of this equation, it is possible to determine the mean value of the coefficient of friction along the length of the tube. The approximate character of the theory of the boundary layer laid the foundation of the deduction for the calculation dependences, and the series of assumptions adopted also condition the approximate nature of the formulas obtained, requiring experimental substantiation.

V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1339. Starosolszky, O., Design charts for computation of head losses in conduits (in Hungarian), Proceedings of the Research Institute for Water Resources, Budapest, no. 4, 19 pp. + 31 charts, 1958.

The friction loss in pipelines is accompanied by *minor losses* due to changes in direction, to manifolds, to changes in cross section and to fittings mounted in the pipeline. These losses result from turbulence, separation and dead spaces following the acceleration and subsequent deceleration of water at the above local resistances.

In practical computations the local head loss (in some instances energy loss) h measured in height of water column is expressed in terms of the velocity head $\frac{v^2}{2g}$ pertaining to a characteristic cross section as

$$h = \zeta \frac{v^2}{2g}$$

where ζ is the empirical loss coefficient depending within the turbulent range of flow upon the character and on significant dimensions of the element in consideration. In some the loss coefficient is a function of the Reynolds number as well. Loss coefficients in the graphs have, in general, been plotted against significant dimensions, striving for up-to-dateness and relative completeness in collecting the experimental material. In computing the loss coefficient at *bends*, the Reynolds number, the surface roughness, the rate of curvature and the central angle have been considered. Data given for welded sharp elbows refer to different angles yet include allowances for interference.

The loss-coefficient of *branch pipes and junctions* depends upon the ratio of pipe diameters, on the angle of bifurcation, on the roundness of corners, on the direction of flow and on the ratio of flow carried by individual branches. Besides data suited for generalization, loss coefficients of individual elements are also given together with suggestions for the most practicable shaping of the bifurcation.

Among losses due to *changes in cross section*, coefficients are given for those occurring at the entrance, at sudden and gradual contractions, at sharp-edged orifices, at sudden and gradual enlargements, and at the outlet.

The loss coefficients of *fittings* are relatively the most uncertain ones. The shape of individual fittings varies with make and thus experimental results do not lend themselves for generalization. In case of controllable fittings the loss coefficient is given for the normal operating condition, besides the complete opening, also for other cases in the function of opening.

For approximate investigation of long conduits the estimation of local losses is often sufficient. In case of estimation, the *equivalent straight pipe length* l_e—the friction loss of which is equal to the loss due to local resistance—is expediently applicable,

$$l_e = \zeta \frac{d}{\lambda}$$

Owing to the dependence of the resistance coefficient λ on many other factors the general use thereof cannot be introduced.

With the loss coefficients obtained from the figures of appendices 2–24, the *loss* h_v can be computed by Chart 25.

The use of the design charts is illustrated by a numerical example in tabulated form. In the appendix, design charts have been developed for the computation of the pressure increase due to

water hammer as well as of the pipe wall for external and internal overpressure. From author's summary

1340. Capdeville, J. B., Different formulas for the computation of head losses in pipe lines (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liq.* **13,** 1, 71–82, Jan. 1958.

1341. Melikyan, G. M., Hydraulic characteristics of automatic water troughs (in Russian), *Izv. Akad. Nauk. ArmSSR, Biol. i S.-Kh. Nauk* **9,** 6, 101–107, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5526.

Results of experiments are made known, which were carried out in 1953 in the laboratory of the agricultural water service section of the Novocher Kass engineering-amelioration institute for the investigation of the structural-hydraulic features affecting the outflow of water through an automatic water basin (the dimension of the outlet pipe of the basin, the inside configuration, the roughness of its inner surface, pressure of water at the valve and so forth). A description is given of the special apparatus used in the experiments and of the principal results of the investigations, and curves are shown to indicate the effect on water consumption of pressure loss and of the resistance of the automatic water basin due to the diameter selected for the outlet pipe.

Yu. M. Savvin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1342. Ertl, W., Stepwise calculation of unsteady discharge (in German), *Wasserwirtschaft* **48,** 10, 266–268, July 1958.

1343. Fedorov, N. N., The determination of the velocity factor C for natural channels (in Russian), *Trudf Gos. Gidrol. In-ta* **110,** 56, 96–102, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6668.

A number of questions are elucidated associated with the determination of the velocity factor C in the Chezy formula for the volume of flow. The problems of the kinematic structure of the flow are examined in particular detail, as well as the determination of the mean velocities, coefficient of roughness, absolute and relative roughness, etc. The fundamental conclusions of the author are:

(1) The most reliable method for the quantitative evaluation of roughness in a natural channel is the determination of the absolute roughness of the latter by means of direct measurement of characteristic protuberances of the bottom, or by a stereophotographic record of the latter.

(2) In selecting the value of the coefficient of roughness n from tables, the most reliable for determining the velocity factor C will be found to be the well-known formula of Pavlovsky and the formula of Agroskin—$C = 17.72\ (k + \log R)$ where k = the smoothness parameter, and R hydraulic radius. The use of Manning's formula (assuming a constant value of n) may lead to errors of 15% or more.

(3) Where the value of the absolute roughness of a particular section of the channel is known, C can be determined by the formula of Manning or Agroskin, while n can be calculated from the relationship

$$n = \frac{0.127\, H^{1/4}}{\ln(H/\Delta) + 2.40}$$

where H = mean depth, Δ value of the absolute roughness (height of the protuberances).

Extensive tabular and graphical material is included.

Yu. M. Savvin

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Book—1344. Delfs, J., Friedrich, W., Kiesekamp, H., and Wagenhoff, A., Influence of forest and clearing on runoff, water balance and soil erosion. Vol. 3 [Der Einfluss des Waldes und des Kahlschlages auf den Abflussvorgang, den Wasserhaushalt und den Bodenabtrag], Hannover, Aus dem Walde, 1958, 223 pp. + appendix.

Results of 5 years of investigations in Upper Harz, Saxonia, 1948–1953, are presented in a series of articles. Titles: Purpose of investigation, layout of stations and their instruments, physiography (4 basins of 215, 186, 74 and 93 acres, 3 were under forest cover, one clear cut); Geology, forest cover, climate, precipitation, interception and stem flow, runoff (clear-cut basin showed higher average flow during summer, lower during winter); Yield from springs, floods (no clear relationship found); Surface runoff and soil erosion (3 times greater in clear cut); Runoff during drought; Water balance of the clear cut and of the forest-covered area; Comparison with other investigations.

Appendix contains all observation data in extenso. English summary is given on pages 215–219. This symposium is of very great interest for hydrologists and foresters.

S. Kolupaila, USA

1345. Shifrin, S. M., and Ivanov, G. V., Modelling of vertical settling tanks (in Russian), *Nauch. Tr. Leningr. Inzh.-Stroit. In-ta* no. 20, 38–58, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5790.

A description and results are given of laboratory investigations of vertical settling tanks with the object of obtaining a rational system for construction of settling tanks for the reconditioned cleansing, channelled, installations of the Leningrad meat combine (8 vertical round settling tanks of customary design with diameter of 6 m and height of 8 m). The investigations were carried out in the LISI laboratory on models (with scale 1:15) of Plexiglas. The modelling was executed on the system proposed by A. G. Averkiev [*Vses. N.-I. In-T Gidrotekhn.* 1952], based on the modelling of a free surface with the substitution of an unforced current by a pressurized flow. Authors feel justified in evaluating the hydraulic characteristic of the work of the settling tanks by the water circulation coefficient, understanding in so doing the relation between the sums of the transit and doubled circulation discharges of water and the transit discharge in a typical section of the settling tank. Kh. A. Navoyan

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Book—1346. Yevdjevich, V. M., Investigation methods for development of water power resources (in Serbian and English: a doctoral thesis in the Serbian Academy of Sciences, also Power resources of Yugoslavia), Belgrade, Yugoslav National Committee of the World Power Conference, 1956, 214 pp.

A very thorough study of the complicated problem of rational water power development. Titles of particular chapters show variety of discussed topics: Laws of increase of production of electric power. Methods of investigation of water resources. Theoretical potential of water power: from precipitation, from runoff, from river flow, from low flow below the average discharge. Power available for economic use. Topographical and hydrological data. Duration curves of discharge and power. Geographic distribution of water resources. Mean annual sequence. Long-term fluctuations. Compensation of different regimes. Q-H diagram.

A systematic investigation of available water power resources of Yugoslavia illustrates this valuable treatise. Outlines for a rational planning are laid by the author when he forecasts an increase in water power use in Yugoslavia from 1.2 billion kWh in 1950 to 50 to 60 billion at the end of this century. Summaries in French, Russian, Spanish, German and Italian conclude this excellent and perfectly edited dissertation.

S. Kolupaila, USA

1347. Rozhdestvenskii, N. G., First aerodynamical three-dimensional model in the hydraulic laboratory M. E. I. (in Russian), *Trudi Mosk. Energ. In-ta* no. 19, 150–153, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5561.

The technical side of carrying out investigations of the construction period of one hydro-installation is set out in detail, in accordance with the method proposed by A. G. Averkiev [*Izv. Vses. n.-i. in-ta Gidrotekhn.* **47**, 1953], for the hydraulic modelling on unpressurized currents on supported aerodynamical models. Some interest is furnished by the author's brief notes on the experiments carried out on the aerodynamic model on the investigation of erosion in the region of distribution of the eroded material. It is regretted that no deductions are put forward on the results of these experiments. M. E. Faktorovich

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1348. Azrichovich, S. S., Hydrodynamic action of a stream in the process of bottle washing (in Russian), *Spirt. Promst.* no. 2, 10–14, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5525.

Incompressible Flow

(See also Rev. 1221, 1336, 1348, 1392, 1398, 1406, 1408, 1419, 1430, 1490, 1495, 1517, 1560, 1563)

Book—1349. Dryden, H. L., Murnaghan, F. P., and Bateman, H., Hydrodynamics, New York, Dover Publications, Inc., 1956, 634 pp. $2.50. (Paperbound)

1350. Taneda, S., Negative Magnus effect, *Rep. Res. Inst. Appl. Mech., Kyushu Univ.* **5**, 20, 123–128, 1957.

In certain range of Reynolds number and rotational speed, spheres and cylinders rotating about a cross flow axis in a uniform stream suffer the lifts which have direction opposite to those in ordinary Magnus effect.

In the present experiment the condition under which the negative Magnus force takes place was clarified for the case of a sphere, and it was found that this remarkable effect can be explained as a transition effect of the boundary layer from laminar to turbulent flow.

The photographs of the actual flow pattern around a rotating sphere were also taken by means of aluminum dust method, and the difference between the two flow-patterns of ordinary Magnus effect and negative Magnus effect was revealed.

From author's summary

1351. Misicu, M., Note on the determination of velocities in the case of three-dimensional incompressible fluid motions (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 177–193.

In developing a general method of determining solutions of steady three-dimensional incompressible, perfect fluid problems, author, in analogy to the use of analytic functions for the plane case, finds solutions for the hypercomplex velocity $V = -u + iv + jw$. He shows that a class of functions, derivable from spherical functions, satisfies the equations of motion. He then proceeds to tabulate elementary solutions in terms of these functions, for example, uniform motion, a point source, a point vortex, a source and a vortex in the presence of a sphere, a vortex and source, and several others. W. Daskin, USA

1352. Haemmerlin, G., The stability of flow in a curved channel (in German), *Arch. Rational Mech. Anal.* **1**, 3, 212–224, May 1958.

Small disturbance theory for incompressible two-dimensional steady laminar basic flow, when the width of the channel is constant and small in comparison with the radius of curvature. A new treatment of this problem, using exact methods, is given in order to examine the different results from investigations by Dean [*Proc. Roy. Soc. Lond.* (A) **121**, 402–420, 1928] and by Yih and Sangster [AMR **10** (1957), Rev. 4057]. The differential equations for the vortex instability are transformed into integral equations, for which the lowest eigenvalue can be calculated by an iteration process as a function of the mutual distance of the vortices. At the same time the corresponding eigenfunctions are found so that the structure of the vortices can be described. Dean's result agrees fairly well with the lower limit of stability determined by this method, whereas the results by Yih and Sangster are found to be in error. J. C. Rotta, Germany

1353. Reid, W. H., On the stability of viscous flow in a curved channel, *Proc. Roy. Soc. Lond.* (A) **244**, 1237, 186–198, Mar. 1958.

Stability of viscous flow in a curved channel formed by two concentric cylinders due to a pressure gradient acting around the channel is considered when the spacing between the cylinders is small compared with their radii. Condition for neutral stability is determined by solving approximately the linearized disturbance equations. It is found that instability first sets in when the parameter $R(d/R_1)^{1/2}$ attains a value of about 36, in close agreement with earlier results of Dean [*Proc. Roy. Soc. Lond.* (A) **121**, p. 402, 1928], where d is the spacing, R_1 the radius of inner cylinder, and R the Reynolds number based on d and the mean velocity of undisturbed flow. The pattern of motion which sets in is of the familiar cellular type but with a marked asymmetry.

The method of solution differs from that of Dean in the form of series expansion for disturbance velocities. Instead of a conventional Fourier representation as used by Dean, a set of orthogonal functions which automatically satisfy more boundary conditions is employed with the result that the size of the secular determinant that must be taken to achieve sufficient accuracy can be reduced. Moreover, the disagreement of recent results of similar work of Yih and Sangster [AMR **10** (1957), Rev. 4057] with those of Dean is made clear in the light of the present analysis.

I. Tani, Japan

1354. Duffy, R., and Li, T. Y., Shear flow past a circular cylinder in an incompressible fluid of small viscosity, AFOSR TN 57-715 (Rensselaer Polytechnic Inst., Dept. of Aero. Engng. TR AE 5707; ASTIA AD 136 708), 29 pp., Oct. 1957.

The boundary-layer characteristics about a circular cylinder in an incompressible fluid stream of symmetrical velocity distribution have been examined. Boundary-layer results are expressed in the form of an infinite series expansion in terms of the free-stream velocity distribution and the distances normal to and along the body surfaces.

Preliminary results indicate that small free-stream vorticity acts in a manner similar to induced pressure gradients along the body surface and as such has pronounced effects on boundary-layer separation, boundary-layer growth and shear stress.

From authors' summary

1355. Milliat, J.-P., Experimental study of a turbulent air flow in a diverging two-dimensional channel (in French), *Publ. Sci. Tech. Min. Air, France*, no. 335, 134 pp., 1957.

Theoretical consideration of the flow through divergent diffuser, description of wind tunnel, and method of measurement are given. Angle of divergence is chosen to be 2, 4, 6 and Reynolds number, based on the breadth of diffuser, 33,000, 52,000 respectively. The velocity distribution and specter of velocity fluctuation of 12 stations are measured. Side walls of diffuser are not parallel but widen to downward due to the fact that a remarkable slip occurs along the walls when they are parallel. In order to get two-dimensional flow, such consideration will be necessary, but this can be considered as a proof of existence of slip along wall, which is contradictory to the present theory. The adopted method of correc-

tion for turbulence is questionable. The experiments show that the energy of turbulence increases with the angle of divergence.

M. Kataoka, Japan

1356. Lieber, P., and Wan, K.-S., A principle of minimum dissipation for real fluids (in English), 9th Congrès Intern. Méch. Appl., Univ. Bruxelles 1957; **2**, 114-126.

A principle is postulated that flow patterns of incompressible viscous fluid consistent with the conservation of momentum and boundary conditions minimize the time rate of energy dissipation. Admissible flows are restricted to two-dimensions, and are defined by a stream function satisfying the biharmonic equation. The vorticity is found in general to be time-dependent, but it is suggested that in a region of rotational flow bounded by irrotational flow the vorticity, together with the stream function, are reasonably time-independent.

In order to obtain an approximate solution compatible with the boundary conditions for the flow past a circular cylinder, discrete vortices are introduced forming a region of rotational flow which is virtually terminated, thus producing finite energy dissipation.

The approximate flow patterns for flow past a circular cylinder, a flat plate, and between flat parallel plates are depicted diagramatically.

E. E. Jones, England

1357. Hedman, S., Method for computing the velocity distribution in a curved duct, Roy. Inst. Technol., Div. Aero., Stockholm, KTH-Aero TN 36, 16 pp. + 15 figs., 1957.

In designing air ducts it is frequently essential to be able to compute the velocity distribution in order that the risk of separation may be assessed. Author uses elementary theory to develop a method to compute the velocity distribution in a curved duct of varying cross section.

Proceeding from the equations for a plane vortex, author introduces effects of contraction and combines with equation of continuity to derive two first-order differential equations. These are solved by iteration for a particular duct and the results verified by experimental observations which show satisfactory agreement with theory. Derived equations are for incompressible flow but compressible flow problems could be solved by an extension of the method.

W. DeLapp, USA

1358. Rimoldi, R. F., Clifford, W. D., and Bacigalupi, R. J., Effect of air pressure on vortex-shedding frequency of cylinders, *J. Aero/Space Sci.* **25**, 8, p. 532 (Readers' Forum) Aug. 1958.

1359. Abramov, F. A., and Podolsky, V. A., The investigation of mine shaft ventilation by means of models (in Russian), *Izv. Dnepropetr. Gorn. In-ta* **23**, 133-139, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6516.

A method of electrical analogy is proposed for determining the total resistance in a system of underground workings and the quantity of air flowing through them. Modelling is performed on the basis of Ohm's law, introducing a coefficient of proportionality permitting correlation between this linear law and the square law of the aerodynamic resistance in the system of workings. The electrical analog is assembled with 25-watt electric lamps operated at 127 volts. An example is given.

V. I. Khanzhonkov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1360. Klyachko, L. S., A more accurate method of determining the theoretical coefficients of resistance of ducts of different profile (in Russian), *Trudi Nauch. Sessii Vses. N.-i. In-ta Okhrany Truda* no. 1, 79-92, 1954 (1955); *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6655.

A method is presented for the analytical determination of the resistance coefficients of curved ducts. Expressions are set up for determining: (a) the degree of compression of the flow when deflected in a curved duct; (b) the limits of formation of steady compression of the flow; (c) the principal coefficient of resistance caused by the compression of the flow with consequent expansion; (d) the additional resistance coefficient at the steady section of the flow below the bend; and (e) the length of the section of steady flow following on its constriction.

I. E. Idel'chik

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1361. Mologin, M. A., Wave motion on the surface of separated flow in horizontal pipes (in Russian), *Zh. Tekh. Fiz.* **26**, 8, 1823-1835, Aug. 1956.

The "wavy" flow regime for two-phase (air-water) pipe flow is investigated in detail [for background, see lead article, AMR **11** (1958); p. 10]. In earlier paper [*Dokladi Akad. Nauk SSSR* **51**, 3, 1946] author classified seven flow regimes in terms of, for each pipe diameter, ratio (0 to 1) of gas volume flow to mixture volume flow and mixture velocity (0.15 to 20m/sec). Flow regimes of interest here are: I-Separated (stratified or wavy); II-Plugged w/o froth; III-Plugged with froth after bubbles; and IV-Plugged with froth between bubbles. Author found that transition from I to II, III, or IV could be given by an empirical formula involving above flow variables and pipe diameter. In this paper author reports detailed measurements of wave amplitude, period and propagation speed with the same pipes (25, 50, 75 or 100 mm). For wave amplitude and period, empirical formulas are found which include the effect of pipe diameter.

Author's detailed description of wavy regime appears to be new and useful. The usefulness of his particular choice of flow variables and empirical formulas should be investigated for extension to other fluids.

A. G. Fabula, USA

1362. Pykhteev, G. N., Exact solution of the problem on Kirchhoff's discontinuous flow for one family of contours (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **108**, 1, 34-37, May 1956.

Author has investigated discontinuous two-dimensional flows of an ideal fluid past the contours of a category form defined by the equations:

$$x = \int_{\pi/2}^{\delta} f(\mu, m, \delta) \cos \delta \cdot d\delta; \quad y = \int_{\pi/2}^{\delta} f(\mu, m, \delta) \sin \delta \cdot d\delta,$$

where x, y are the Cartesian coordinates, δ the angle between the local tangents on the contour and the x - axis, and μ, m two parameters, which satisfy the relations $0 \leqslant \frac{\pi}{2} - \delta \leqslant \mu \cdot m$; $0 \leqslant \mu \leqslant \frac{\pi}{2m}$. The contours are of parabola shape and are symmetric to the x - axis.

The computation is made according to the method of the conformal transformation, it being assumed *arbitrarily* that the pressure is uniform at all points of the contour separating the flow and the dead-water region. The computed values of the resistance coefficient have been plotted in a diagram.

Reviewer comments that the title of the publication is misleading. The results cannot be termed an "exact" solution of the problem, as the computation is based on the aforementioned arbitrary assumption which, while giving satisfactory results, does not provide exact solutions.

M. Strscheletsky, Germany

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 1350, 1404, 1413, 1433, 1439, 1449, 1450, 1451, 1452, 1491, 1499, 1501, 1504, 1541, 1561, 1566, 1581, 1636)

1363. Sullivan, R. D., and Donaldson, C. duP., Some solutions of the Navier-Stokes equations with time dependent density, *J. Aero. Sci.* **25,** 5, 337–338 (Readers' Forum), May 1958.

Note gives solutions of the Navier-Stokes equations under the following assumptions: constant viscosity, density only time-dependent, pressure only time-dependent, all other quantities dependent upon one space coordinate and time. By introducing the time integral over the density as a new variable the equations of motion reduce to the one-dimensional heat equation. Example shows flow along an infinite flat plate suddenly set in motion, assuming that the density increases exponentially with time. Boundary-layer thickness as function of time grows first and then decreases because of the decreasing kinematic viscosity.

K. Pohlhausen, USA

1364. Martinot-Lagarde, A., Similitude in two-dimensional flow in the neighborhood of a bottle neck of a nozzle (in French), *C. R. Acad. Sci., Paris* **246,** 17, 2454–2456, Apr. 1958.

1365. Chernyi, G. G., Swirl flows of compressible gas in ducts (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 6, 55–62, June 1956.

Author discusses radial equilibrium in a steady isentropic flow of a perfect gas in axisymmetric ducts in slowly varying cross-section area. Expressing stagnation pressure, stagnation temperature and circulation as arbitrary functions of a stream function, the problem is reduced to numerical solution of a system of two first-order total differential equations.

Assuming small swirl and small variations in entropy and in total enthalpy, linearization of equations gives a closed form solution. Comparison is then made between linearized case and circulation-free case.

C. P. Kentzer, USA

1366. Skobelkin, V. I., The principle of least flow potential (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **108,** 5, 787–790, June 1956.

Short note on a variational principle for calculating problems of gas dynamics. The theory is based on the introduction of a pair of functions ψ, δ in the three-dimensional case instead of one stream function ψ in the two-dimensional case. The momentum and energy theorems are used for establishing two equations for the normal components of rot v, which can be simplified for adiabatic flow.

W. Wuest, Germany

1367. Rakhmatulin, Kh. A., Principles of gas dynamics for mutually permeable flows of compressible media (in Russian), *Prikl. Mat. Mekh.* **20,** 2, 184–195, Mar.–Apr. 1956.

Paper concerns the common motion of a mechanical mixture of media consisting of relatively small particles. The motion of non-stiffened concrete, of gas-fed oil, etc., are examples of such motion. Paper contains important contributions to the theory of this kind of motion. It is assumed that the dimensions of the moving particles are small in comparison with the range through which the variations of the kinematical and dynamical parameters of the flow are sensible. In its essential features Rakhmatulin's theory is a generalization of Zhukov's theory of filtration. A complete system of differential equations is deduced in the general case of a mixture having an arbitrary number of components. As special cases are treated mutually permeable motion of two compressible media, motion of incompressible media, steady and nonsteady motion of two mixtures in a pipe.

J. Beranek, Czechoslovakia

1368. Mills, B., and Cole, B. N., Compressible gas-flow in commercial pipes, *Instn. Mech. Engrs. Proc.* **171,** 19, 617–632, 1957.

The main object has been to facilitate economic design of pipework for compressible flow; it being recalled that the cost of pipework in a given installation may not infrequently exceed the cost of compressor plant. It is found that the conclusion reached by Keenan and Neumann, namely, that compressible, subsonic flow in "smooth" pipes is independent of Mach number and depends upon Reynolds number exactly as for incompressible flow, may be extended to commercial pipes of appreciable wall-surface roughness. While nonadiabatic flow is also examined, attention is mainly given to adiabatic flow; and various devices, tabular, graphical, and nomographical, are proposed to assist rapid estimation of such quantities as flow rate, pressure drop, maximum power transmitting capacity, etc.

Encouraging correlation is found to exist between directly measured wall-surface roughness, as represented by the British Standard center-line average index, and roughness as expressed hydrodynamically by the equation of Colebrook and White. This points to the practicability of predicting the flow characteristics of large pipes, for which flow tests may be difficult until in situ, by surface measurement alone.

From authors' summary

1369. Helliwell, J. B., Two-dimensional flow at high subsonic speeds past wedges in channels with parallel walls, *J. Fluid Mech.* **3,** 4, 385–403, Jan. 1958.

By aid of the hodograph method investigations are made of the plane flow of an inviscid isentropic gas at high subsonic and sonic speeds past a finite wedge of small angle at zero incidence in a channel with parallel walls. Two models of the flow are discussed: (1) the model of Cole [AMR **4** (1951), Rev. 4527] with the sonic line from the shoulder extending completely across the channel at right angles to the wall; (2) the model of Hilliwell-Mackie [AMR **11** (1958), Rev. 2733] in which there is a free-stream breakaway from the shoulder of the wedge and the velocity far downstream may be either uniformly subsonic or sonic.

Formulas are obtained for the drag coefficient in both cases, and a high degree of both qualitative and quantitative agreement is found. On the basis of the free streamline theory the tunnel-wall correction for the drag coefficient is given in terms of the width of the tunnel and the upstream Mach number; this correction is, in general, small within the range of validity of the theory, which does not apply unless the width of the tunnel is wider than the length of the wedge by a factor of the order 10.

Moreover the relation is given which necessarily exists between upstream Mach number, channel width and wedge angle for the first model, and between upstream Mach number, channel width, wedge angle and downstream Mach number for the second model. An expression is also obtained for the width of the wake.

The results of the investigation of the flow with free-stream breakaway past a wedge in a channel can be applied to the plane jet flowing from a convergent nozzle through a region of constant pressure into a duct with parallel walls. The special case is considered of the two-dimensional sonic jet flowing through a convergent nozzle into a region of constant pressure which has the value associated with the sonic velocity.

E. M. de Jager, Holland

1370. Maeder, P. F., Solutions to the linearized equation for transonic flows and their comparison with experiment (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2,** 19–24.

Comparisons are made between a linearized theory for transonic flow over wings and bodies and some wind-tunnel and flight test

results. The linearization used here involves the assumption that the coefficient of the velocity term is a constant.

Pressure distributions, local Mach numbers and drag coefficient calculations agree quite well with experiments. The major inaccuracy appears to arise from viscous effects at the trailing edge.

L. H. Schindel, USA

1371. Keune, F., A contribution to an approximate calculation of the flow on pointed halfbodies of revolution in the lower transonic range (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 25-33.

Based on the linearization procedure which assumes that the coefficient of the axial velocity is a constant, the transonic flow over the forward half of a body of revolution is calculated. The result is in agreement with other linear methods. The solution differs from that of Maeder [see previous review] in the method of determining the constant. Similarity laws are given for full bodies valid also at angles of attack and for wing-body combinations.

L. H. Schindel, USA

1372. Haines, A. B., Wing section design for sweptback wings at transonic speeds (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 34-39.

A discussion is given of the effects of variations in chordwise thickness distribution on the drag rise Mach number. Experiments confirm that the onset of the drag rise can be delayed by adjusting the maximum thickness point and the shape of the thickness distribution. The paper would be easier to understand if the objectives of the designer were more clearly in evidence.

L. H. Schindel, USA

1373. Chang, C.-C., and Chu, W.-H., Transonic channel flow after slight modification of inner boundary (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 50-60.

This analysis represents another contribution to the old argument over the non-existence of neighboring transonic potential flow after a small adjustment of the boundary. In this case, the authors consider a smooth perturbation of the boundary of a channel flow. Numerical solutions are given for the nonlinear equation for two-dimensional rotational flow.

The results indicate that neighboring transonic potential flows do in fact exist for the perturbed boundary. Although in the derivation of the neighboring flow, a perturbed solution was assumed, the conclusion appears to be justified. The authors note that the position of the sonic line is changed by the boundary perturbation. They offer this point as an explanation of the source of error in proofs of the non-existence of perturbed solutions.

L. H. Schindel, USA

1374. Czarnecki, K. R., and Jackson, Mary W., Effects of nose angle and Mach number of transition on cones at supersonic speeds, *NACA TN* 4388, 8 pp. + 7 figs., Sept. 1958.

An investigation has been made to determine the transition characteristics of a group of smooth, sharp-nosed cones varying from $10°$ to $60°$ in included apex angle over a Mach number range from 1.61 to 2.20 and a range of Reynolds number per foot from about 1.5×10^6 to 8×10^6. Increasing the cone angle is shown to decrease slightly the transition Reynolds number, whereas the effects of changes of Mach number and unit Reynolds number are negligible. When transition occurred within 15 to 20% of the model length from the base there was a dropoff in transition Reynolds number.

From authors' summary

1375. McCune, J. E., The three-dimensional flow field of an axial compressor blade row—subsonic, transonic, and supersonic, AFOSR TN 58-72 (Cornell Univ., Grad. School of Aeronautical Engineering; ASTIA AD 148 116), 245 pp., Feb. 1958.

A linear small-perturbation theory for the description of the steady-state flow field associated with an axial compressor blade row is developed by superposition of cylindrical wave functions. The method is valid for both subsonic and supersonic axial Mach numbers, and for thin, but otherwise arbitrary, blade geometries. In particular it is applicable to the transonic compressor, operating with relative Mach numbers that are subsonic at the hub and near sonic or supersonic at the tips. The general formulas are applicable to all shrouded axial devices, whether of high or low solidity, but special attention is given to configurations with a large number of blades. Since the periodicity in the circumferential direction determines the order of the radial functions, advantage is taken of the large number of blades through the exploitation of the asymptotic formulas for Bessel functions of large order. In the subsonic and supersonic cases this makes possible the derivation of three-dimensional corrections to the classical cascade approximations.

The wave drag and pressure distributions associated with a blade row having twisted blades of radially decreasing thickness-to-chord ratio and simple profiles are computed for several Mach numbers, especially in the transonic regime.

A brief outline is given of the modifications necessary to handle the lifting case with distributed loadings.

From author's summary by F. W. Riegels, Germany

1376. Krasil'shchikova, E. A., Unsteady motion of a finite span wing in a compressible medium (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **117**, 5, 777-780, 1957 (Translation by Morris D. Friedman, Inc., 67 Reservoir St., Needham Heights 94, Mass., K-171, 5 pp.)

Author discusses small-perturbation theory of compressible fluid flow about a slender finite wing of arbitrary planform at an angle of attack in the supersonic regime. The velocity potential is derived as an integral, using the source distribution method. For supersonic speeds and suitable planform the region of integration is interior to the surface mapping the motion of the wing contour in space-time, hence the integral can in general be evaluated. Author's previous work [AMR **10** (1957), Rev. 1548] is extended by brief qualitative discussion of the general planform case, using a geometric visualization of the space-time trajectory of the wing and the domains of influence of the sources

R. A. Stern, USA

1377. Bogdonoff, S. M., and Vas, I. E., Experimental studies at Mach numbers 12 to 19 of conical and blunted bodies at zero angle of attack, AFOSR TN 58-841 (Princeton Univ., Div. of Aero. Engng. Rep. 435; ASTIA AD 203181), 8 pp. + 21 figs., Sept. 1958.

An experimental study on conical and blunted bodies was carried out at Mach numbers between 12 and 19 using the Princeton University Helium Hypersonic Tunnel. Pressure distributions and schlieren photographs were obtained for bodies with cone half angles varying from $10°$ to $45°$. Comparison with the theoretical inviscid and Newtonian pressures corrected for normal shock losses were made. The pressures on a body without corners can be predicted quite well. A corner at the junction of the nose section and conical afterbody results in large variations between the measured values and predicted ones. The pressures on the conical bodies were not affected by the nose shape for that part of the body downstream of a station located at $1\frac{1}{2}$ times the nose bluntness diameter.

From authors' summary

1378. Sabol, A. P., Measurements in a shock tube of heat-transfer rates at the stagnation point of a 1.0-inch-diameter sphere for real-gas temperatures up to 7,900°F, *NACA TN* 4354, 9 pp. + 1 table + 5 figs., Aug. 1958.

Heat-transfer rates were determined at Mach numbers between 6.4 and 13.9 from measurements of the surface-temperature change with time of a thin-film platinum resistance surface thermometer.

The test results are presented and compared with the predictions of two theories, and the compatibility of these results with other experimental results obtained with both a thin-film surface thermometer and a calorimeter-type gage is pointed out. Data from tests in which a thin-film thermocouple was used are also included for comparison. From author's summary

1379. **Truitt, R. W., Minimum-drag cone frustum at hypersonic speeds,** *J. Aero/Space Sci.* **25,** 8, 529–530 (Readers' Forum), Aug. 1958.

1380. **Martin, E. D., Inviscid hypersonic flow around spheres and circular cylinders,** AFOSR TN 58-448 (Rensselaer Polytechnic Inst., Dept. Aero. Engng., TR AE 5807; ASTIA AD 158254), 55 pp. + 19 figs., Apr. 1958.

Paper deals with constant-density layer approximation to hypersonic flow about sphere and cylinder. Shock and body are taken concentric, so results duplicate those already obtained by Lighthill [*J. Fluid Mech.* **2,** 1, 28–31, Jan. 1957] and Witham [AMR **11** (1958), Rev. 4117] although analysis of present paper is more involved. Included are graphs of a number of useful physical quantities which are not contained in the cited works, and a comparison with the work of Li and Geiger [AMR **10** (1957), Rev. 2979] in which curvature effects were neglected.

R. W. Detra, USA

1381. **Eggers, A. J., Jr., Hansen, C. F., and Cunningham, B. E., Stagnation-point heat transfer to blunt shapes in hypersonic flight, including effects of yaw,** *NACA TN* 4229, 50 pp. + 4 figs., Apr. 1958.

Authors develop a rough approximate theory for the flow along the stagnation streamline from the shock to the nose of a symmetrical blunt body. The model is to split the regime into a nonviscous, incompressible flow after the shock and a compressible, viscous, but low velocity flow adjacent to the nose. A further basic assumption is to regard $\partial^2 p/\partial y^2$ (y normal to the stagnation streamline which coincides with x-axis) as constant along the stagnation streamline. Simple expressions for the detached distance and heat transfer at the nose are obtained for two-dimensional bodies with or without yaw, and for body of revolution. Real gas effects such as dissociation may be conveniently taken into account. A sizable reduction in heat-transfer rate by large yaw is predicted. S. F. Shen, USA

1382. **Adams, M. C., and Probstein, R. F., On the validity of continuum theory for satellite and hypersonic flight problems at high altitudes,** *Jet Propulsion* **28,** 2, 86–89, Feb. 1958.

A study is made of the validity of continuum flow theory applied to hypersonic flight in a rarefied gas. Order-of-magnitude estimates are made to establish the flight conditions for which a continuum analysis should be applicable in the stagnation region of a blunt body. Differential equations are presented for the flow in the stagnation region for the flight regime where neither boundary-layer theory nor free-molecule theory is valid. The results of the study are applied to the problem of re-entry of a satellite, and it is concluded that a continuum analysis, with no slip at the body surface, is valid for the flight conditions where heating is important.

From authors' summary by J. N. Aguirre, Argentina

1383. **Guiraud, J.-P., On the shock-expansion method** (in French), *C. R. Acad. Sci., Paris* **245,** 21, 1778–1782, Nov. 1957.

Author investigates validity of shock-expansion theory for hypersonic flow past an airfoil. When characteristic co-ordinates α, β with associated length parameters A, B are used, the closeness of approximation given by this theory depends on the smallness of the quantity $\eta = B\theta_\alpha/(A\theta_\beta)$. Two conditions (which imply a knowledge of the flow field) are derived for η to be small. A minus sign is omitted in second set of characteristic equations.

See also Mahony [AMR **9** (1956), Rev. 1153] and Whitham [*J. Fluid Mech.* **4,** 4, 337–360, Aug. 1958].

H. C. Levey, Australia

1384. **Chernyi, G. G., Hypersonic flow past an airfoil with a slightly blunted leading edge** (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **114,** 4, 721–724, 1957 (Translated from Russian by M. D. Friedman, 67 Reservoir St., Needham Heights, Mass., C-112, 5 pp.).

Author briefly presents an approximate solution by means of piston analogy, consisting of applying energy and momentum equations to the perturbed gas mass concentrated in the thin layer between shock front and body, and solving for shock motion. Result is found to be close to exact solution of the strong explosion problem, which is in satisfactory agreement with experimental results on hypersonic blunt plate flow.

Paper lacks sufficient details to be conveniently studied. Especially no explanation is given on the derivation of formula for shock-wave shape. A simple figure showing basic situation and its connection with piston theory, as well as some indications on simplifications resulting from hypersonic flow character would be of great help for the conventional aerodynamicist.

P. Schwaar, France

1385. **Huber, P. W., Tables and graphs of normal-shock parameters at hypersonic Mach numbers and selected altitudes,** *NACA TN* 4352, 12 pp. + 2 tables + 10 figs., Sept. 1958.

Tables and graphs of normal-shock parameters corresponding to six selected altitudes below 300,000 feet and for temperatures behind the shock from 2,000 K to 11,000 K are presented for real air in thermal and chemical equilibrium. The altitude data and real-air thermodynamic data used in the computations represent reliable values for application to aerodynamic flight in the atmosphere. Values of the normal-shock Mach numbers, flight velocity, enthalpy behind the shock, and of pressure, density, temperature, and velocity of sound ratios are presented to show variations with temperature behind the shock, flight Mach number, and altitude.

From author's summary

1386. **Friedman, R., and Boldman, D. R., Detached shock waves ahead of gas-sampling probes,** *J. Aero/Space Sci.* **25,** 8, 526–527 (Readers' Forum), Aug. 1958.

1387. **Cowan, R. D., Properties of the Hugoniot function,** *J. Fluid Mech.* **3,** 5, 531–545, Feb. 1958.

Differentiation of the Hugoniot function

$$H(p, v) = E(p, v) - E(p_0, v_0) + \tfrac{1}{2}(p + p_0)(v - v_0)$$

and use of the first and second laws of thermodynamics leads to the relation $dH = T\,dS + dA$, where dA is the element of area in the (p, v) plane swept out (in a counter-clockwise direction) by the line segment $(p_0, v_0) \to (p, v)$ as the point (p, v) is moved from some point (p_1, v_1) to a neighboring point $(p_1 + dp_1, v_1 + dv_1)$. This relation, together with rather general assumptions regarding the shape of the isentropic curves $dS = 0$ for the material behind the shock, makes possible the geometrical derivation of a number of properties of the function H and of the Hugoniot curves $dH = 0$.

From author's summary

1388. **Lun'kin, Iu. P., The structure of shock waves,** *Soviet Phys.-Tech. Phys.* **2,** 6, 1169–1175, Feb. 1958. [Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **27,** 6, 1276–1281, June 1957, by Amer. Inst. Phys., Inc., New York, N. Y.]

A scheme is presented for estimating the pressure, density, and temperature at the beginning and end of various zones assumed to occur in shock waves. The zones correspond to the various physical processes occurring in shock waves, which include establishment of the Maxwellian velocity distribution, excitation of the ro-

tary and oscillatory modes of vibration, ionization, and dissociation. The method consists of applying the equations of momentum, energy, continuity, and state to each zone separately. The first zone corresponds to that physical process requiring the least number of collisions for equilibrium, etc. Specific calculations are carried out for oxygen and chlorine. J. N. Nielsen, USA

1389. **Bednarczyk, H., The stability of normal shocks** (in German), *Öst. Ing. Z.* **1**, 2, 85-88, Feb. 1958.

The position of a shock is shown to be statically stable in an accelerating stream, unstable in a decelerating one, by a clever use of shock conditions and perfect-gas, adiabatic flow rules. C. M. Ablow, USA

1390. **Korobeinikov, V. P., Exact solution of the nonlinear problem of an explosion in a gas with variable initial density** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **117**, 6, 947-948, 1957 (Translation by Morris D. Friedman, Inc., 67 Reservoir St., Needham Heights 94, Mass., K-170, 3 pp.).

Flow behind a shock wave due to instantaneous release of finite energy at a point is considered. The general equations (spherical, cylindrical and plane) of adiabatic nonsteady flow are to be solved subject to initial conditions of constant pressure and variable density. The boundary conditions are: vanishing of the velocity at the center of symmetry and the Hugoniot relations for a perfect gas at the shock front. An exact solution is given for an extension of the familiar inverse power relationship between radial distance and initial density. R. A. Stern, USA

1391. **Zingerman, A. S., Correlation between shock wave front pressure and the wave curvature of the energy pulse due to electric discharges in fluids** (in Russian), *Zh. Tekh. Fiz.* **26**, 11, 2539-2540, Nov. 1956.

Boundary Layer

(See also Revs. 1349, 1352, 1404, 1496, 1500, 1516)

1392—**Gortler, H., Tables of universal functions of a new series for the computation of laminar boundary layer** (in German), *Dtsch. Versuchsanstalt Luftfahrt Rep.* 34, 91 pp., Dec. 1957.

A new series method for the calculation of steady laminar incompressible boundary-layer flows was described by author in *J. Math. Mech.* **6**, 1-66, 1957 and used to solve specific problems in two further papers [AMR **10** (1957), Rev. 4106, and AMR **11** (1958), Rev. 3650]. In the present paper, values of universal functions are tabulated which are necessary if the new method is applied to problems of boundary-layer flow along contours with cusped or rounded leading edges. A. R. Mitchell, Scotland

1393. **Brunk, W. E., Approximate method for calculation of laminar boundary layer with heat transfer on a cone at large angle of attack in supersonic flow,** *NACA TN* 4380, 21 pp. + 1 table + 2 figs., Sept. 1958.

By the use of an integral technique, the laminar boundary-layer equations are reduced on the windward generator of the plane of symmetry to a set of simultaneous algebraic equations. The Chapman-Rubesin temperature-viscosity relation and a Prandtl number of 1 are assumed. The method enables the skin-friction coefficients and Stanton number to be calculated in a much shorter time than was needed to obtain exact numerical solutions from the boundary-layer equations. The solutions obtained by this method are, for the most part, within 5 percentage points of the exact solutions. From author's summary

1394. **Lees, L., Note on the stabilizing effect of centrifugal forces on the laminar boundary layer over convex surfaces,** *J. Aero. Sci.* **25**, 6, 407-408 (Readers' Forum), June 1958.

1395. **Granville, P. S., The frictional resistance and turbulent boundary layer of rough surfaces,** *David W. Taylor Mod. Basin Rep.* 1024, 47 pp., June 1958.

Author presents comprehensive resumé of momentum-boundary-layer theory for the smooth, transitional and fully rough regimes. General relation is presented for the frictional resistance of flat plates with arbitrary roughness. Contents include: boundary-layer characteristics from similarity laws, laminar sublayer, transitional sublayer of smooth and rough regions; frictional resistance of plates, smooth and rough regime; engineering roughness; resistance diagrams; prediction of full-scale resistance from plate tests; local skin friction and shape parameters. Local skin friction and velocity profile shape parameter in presence of pressure gradients on rough surfaces are derived in terms of momentum thickness Reynolds number. R. O. Reid, USA

1396. **Willmarth, W. W., Space-time correlations of the fluctuating wall pressure in a turbulent boundary layer,** *J. Aero. Sci.* **25**, 5, 335-336, May 1958.

1397. **Dorand, J. F., Experimental thermal study of the boundary layer in the transition zone of a flat plate at supersonic speed** (in French), *C. R. Acad. Sci., Paris* **246**, 13, 1973-1976, Mar. 1958.

Detailed measurements of total temperature profiles were made in the transition zone of a boundary layer at $M = 1.8$. Calibrated thermocouples having diameters of 0.008 inch were used. Author finds (1) both the velocity and temperature profiles depart from the laminar values at the same distance from the leading edge; (2) in the transition zone the temperature boundary layer is considerably thicker than the velocity layer and the recovery factor at the wall is 1% higher than that in the fully developed turbulent region; (3) the transition zone of the temperature boundary layer is wider than that of the velocity boundary layer.

The measurements seem to be carefully made, having less scatter than any existing ones the reviewer knows of. However, author's reference in his text to a flow separation occurring in the transition zone and the significance of conclusion (3) is difficult to reconcile with the more accepted concept of turbulent spot formation occurring in the transition region. J. Laufer, USA

1398. **Foote, J. R., Flow against a vertical plate with small suction,** *J. Aero. Sci.* **25**, 5, 331-332 (Readers' Forum), May 1958.

Author solves the well-known nonlinear ordinary differential equation for the plane steady flow of a viscous liquid in the vicinity of a stagnation point with a boundary condition at the wall corresponding to constant suction. Since direct solutions are very cumbersome, he applies a method given by H. E. Fettis [AMR **10** (1957), Rev. 807]. Numerical results are given for small suction parameters. K. Pohlhausen, USA

1399. **Crabtree, L. F., Prediction of transition in the boundary layer on an aerofoil,** *J. Roy. Aero. Soc.* **62**, 571, 525-528 (Tech. Note), July 1958.

Author attempts to correlate low-speed transition data by plotting the momentum thickness Reynolds number ($U\,\delta_2/\nu$) at transition versus Thwaite's parameter $m(-U_s\delta_2^2/\nu)$ at transition. The limited test data presented do indicate a unique universal relation between the two parameters but reviewer is aware of much additional data that fail entirely to correlate in subject fashion. Furthermore, B. Melville Jones in 1937 [*J. Aero. Sci.* **5**, 3, 81-101, Jan. 1938, Fig. 13] attempted essentially same correlation without success. Article briefly reviews several other methods of predicting transition and cites some new test data. A. M. O. Smith, USA

1400. Scala, S. M., Surface combustion in dissociated air, *Jet Propulsion* **28,** 5, 340–341, May 1958.

Solutions of stagnation-point boundary-layer equations for a three-component, compressible, chemically reacting gas are briefly summarized for two different models of surface combustion of graphite in dissociated air, viz., (a) nitrogen is an inert diluent and (b) oxygen and nitrogen react completely to form CO and CN. Gas-phase reactions were neglected. Combustion rate for case (a) was found to be of the order of 25% of that for case (b). T. Y. Toong, USA

1401. Broer, L. J. F., Characteristics of the equations of motion of a reacting gas, *J. Fluid Mech.* **4,** 3, 276–282, July 1958.

The equations of motion of a chemically reacting ideal gas are set up and it is shown that the characteristic speed has a singular perturbation-type dependence on reaction rate. The nature of this phenomenon is discussed in terms of the physics of a system slightly disturbed from equilibrium by a perturbation of specified frequency. L. Trilling, USA

1402. Dobryshman, E. M., Approximate solution of certain nonstationary problems for the boundary layer (in Russian), *Prikl. Mat. Mekh.* **20,** 3, 402–410, May-June 1956.

Paper concerns the approximate solutions of the two-dimensional unsteady boundary-layer equations (x,y,t) which are transformed to the dimensionless form. The finite thickness of the boundary layer $\delta(x,t)$ appears as an unknown function in one of the boundary conditions of the differential equation for the velocity component u. The approximate solution of this equation satisfying the corresponding boundary conditions is obtained by two steps of successive approximations. However, this solution contains the unknown function $\delta(x,t)$. A further condition is imposed to the velocity component u, and a differential equation is deduced for the function $f.\delta$, where $f(x,t)$ is the velocity of the outer flow. Once the special form of $f(x,t)$ is given, $\delta(x,t)$ can be determined either analytically or numerically, and all the characteristic parameters of the flow can be found. Several applications of this method are shown. J. Beranek, Czechoslovakia

Turbulence

(See also Revs. 1355, 1396, 1397, 1535, 1584)

1403. Birkhoff, G., and Kampe de Feriet, J., Kinematics of homogeneous turbulence, *J. Math. Mech.* **7,** 5, 663–703, Sept. 1958.

This purely mathematical paper is a rigorous examination, in terms of measure theory, of some of the concepts and quantities associated with random vector fields. The authors attempt to justify some of the heuristic procedures that have been adopted in the study of turbulence; whether they have succeeded is more than this reviewer can say.

G. K. Batchelor, England

1404. Walz, A., New approximate method of calculation of laminar and turbulent boundary layers in compressible flow. Details and examples for case of a pressure gradient (in French), *Publ. Sci. Tech. Min. Air, France,* no. 336, 46 pp., 1957.

Paper appears to be a continuation and supplement to earlier work by the same author ["Nouvelle Methode Approchée de Calcul des Couches Limites Laminaire et Turbulente en Écoulement Compressible," *Publ. Sci. Tech. Min. Air,* no. 309]. Related work is also covered in other recent papers [AMR **10,** (1957), Rev. 1536 and **9** (1956), Rev. 4009].

Method of calculation developed provides for determination of usual boundary-layer characteristics under flow conditions indicated. Present paper gives application of method to an NACA 65 (216)-222 airfoil and to a body of revolution comparable to the V-2 rocket. Computation procedures with tabular arrangements are outlined. Comparison with available experimental results indicates fairly satisfactory agreement.

M. J. Thompson, USA

1405. Leichtmann, D. L., and Orlenko, G. P., The intensity of turbulent exchange above a water surface (in Russian), *Trudi Gl. Geofiz. Observ.* no. 60/122, 51–52, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6881.

Aerodynamics

(See also Revs. 1372, 1376, 1379, 1447, 1460, 1461, 1565, 1566)

1406. Veltkamp, G. W., The drag on a vibrating aerofoil in incompressible flow. Parts I and II, (in English), *Indagationes Math. (A)* **61,** 3, 278–287; 288–297, 1958.

The formulation of pressure, velocity, lift, etc., on a thin airfoil is derived by developing a complex function which can be evaluated along the contour of the airfoil. Evaluation of the integrals is obtained by the use of Cauchy's integral theorem and residue theorem. The analysis of the problem is conducted by assuming the position of the airfoil as defined by

$$y = f(x,t); \qquad -1 < x < 1$$

subject to linearized boundary conditions. Sinusoidal vibrations are represented as

$$f(x,t) = Re\,[f_1(x)\,e^{ikt}]$$

The velocity potential is written as

$$\phi(x,y,t) = Re\,[\phi_1(x,y)e^{ikt}]$$

where ϕ_1 is analytic except for possibly certain boundary points and infinity. A sectionally continuous analytic function $\Omega(z)$ is developed and represented with respect to the velocity potential by the expression

$$\phi_1(x,y) = \tfrac{1}{2}\,[\Omega(z) - \Omega(z)]$$

$\Omega(z)$ is shown to be a regular analytic function in the specified plane and possible singular points are discussed. $\Omega(z)$ is shown to satisfy conditions which correspond to the boundary conditions imposed on ϕ_1 and is written in the form

$$\Omega(z) = \Omega_1(z) + A\Omega_2(z)$$

where $\Omega_1(z)$ and $\Omega_2(z)$ are explicitly defined complex integrals. Author develops the velocity, pressure, lift, etc., for the airfoil in terms of the holomorphic or analytic function $\Omega(z)$.

In reviewer's opinion, author established his argument that the treatment of this class of problem by application of complex function theory as opposed to say integral transform methods is direct and expedient. W. H. Sellers, USA

1407. Sheppard, L. M., Methods for determining the wave drag of non-lifting wing-body combinations, *Aero. Res. Counc. Lond. Rep. Mem.* 3077, 28 pp., 1958.

Theoretical methods of the area-rule, moment of area-rule and transfer-rule for estimating the wave drag of wing-body combinations are discussed. The existing methods of wave-drag estimation, restricted to combination with bodies having continuous surface slope, are extended to those having discontinuous surface slope.

From author's summary by A. Petroff, USA

1408. Kuchemann, D., A method for calculating the pressure distribution over jet-flapped wings, *Aero. Res. Counc. Rep. Mem.* 3036, 17 pp. + 11 figs., 1957.

The title method is presented for wings of nonzero thickness. Effects of camber and of finite aspect ratios are included. The possible effects of sweep have also been indicated.

Y. V. G. Acharya, India

1409. Carpenter, P. J., Lift and profile-drag characteristics of an NACA 0012 airfoil section as derived from measured helicopter-rotor hovering performance, *NACA TN* 4357, 15 pp. + 13 figs., Sept. 1958.

Rotor hovering performance from which the major portion of the synthesized data were derived is presented for tip Mach numbers from 0.28 to 0.70. The principal effect of increasing the blade-tip Mach number is a large increase in blade drag which occurs at a progressively lower blade-mean-lift coefficient as the tip Mach number is increased. These synthesized airfoil data should be useful in helicopter-rotor-performance calculations.

From author's summary

1410. Brown, C. E., and Hargrave, L. K., Investigation of minimum drag and maximum lift-drag ratios of several wing-body combinations including a cambered triangular wing at low Reynolds numbers and at supersonic speeds, *NACA TN* 4020, 24 pp. + 2 tables + 32 figs., Sept. 1958.

Theoretical and experimental data for wing-body combinations with wings of triangular, arrow, and diamond planform are presented for Mach numbers of 1.62, 1.93, and 2.41 and a Reynolds number range of 1.4×10^6 to 0.7×10^6. Included are two each of triangular and arrow planform wings cambered for approximately uniform load at $M = 1.62$ and lift coefficients of 0.08 and 0.20. Liquid-film studies of the flow over the various configurations are also presented.

From authors' summary

1411. Beane, B. J., Curves of minimum wave plus vortex drag coefficient for several wing planforms, *Douglas Aircr. Co. Rep.* SM-22989, 7 pp., Nov. 1957.

Curves have been prepared showing the minimum drag coefficient values which may theoretically be obtained for several different wing planforms at Mach numbers of 2, 3 and 4. The values presented represent the wave plus vortex drag, as computed by linearized theory, for wings that are twisted and cambered such that the surface loading is optimum; that is, the $C_{D_{\text{wave + vortex}}}/C_L^2$ for this loading is a minimum. Skin friction and thickness drags are not included.

From author's summary

1412. Sistino, A. J., The determination of the shear center for a special solid symmetrical airfoil, *J. Aero. Sci.* **25**, 6, 402–403 (Readers' Forum), June 1958.

1413. Holder, D. W., and Lock, R. C., Lateral control at supersonic speeds by means of control surfaces on nacelles or on the fuselage, *J. Roy. Aero. Soc.* **62**, 570, 446–449, June 1958.

1414. Wolhart, W. D., and Thomas, D. F., Jr., Static longitudinal and lateral stability characteristics at low speed of 60° sweptback-midwing models having wings with an aspect ratio of 2, 4, or 6, *NACA TN* 4397, 12 pp. + 3 tables + 24 figs., Sept. 1958.

An experimental investigation was performed to determine the contribution of the various components and combinations of components to the static longitudinal and lateral stability characteristics. Emphasis has been placed on the directional stability characteristics, and the results show that all complete model configurations became directionally unstable in the moderate to high angle-of-attack range. This loss in directional stability is attributed to the large unstable contribution of the wing-fuselage combination and to the decrease in vertical-tail contribution with increasing angle of attack.

From authors' summary

1415. Letko, W., and Fletcher, H. S., Effects of frequency and amplitude on the yawing derivatives of triangular, swept, and unswept wings and of a triangular-wing-fuselage combination with and without a triangular tail performing sinusoidal yawing oscillations, *NACA TN* 4390, 17 pp. + 2 tables + 21 figs., Sept. 1958.

Except for the complete wing-fuselage-tail configuration the results indicate that the damping in yaw and the rolling moment due to yawing increase with angle of attack, and at high angles of attack the oscillatory values are considerably greater than the steady-state values. The values of the oscillatory derivatives for the complete-model configuration are considerably greater than the steady-state values through the entire angle-of-attack range. In general, the greatest changes in yawing derivatives with amplitude and frequency occurred in the low range of amplitude and frequency.

From authors' summary

1416. Demele, F. A., and Powell, K. H., The effects of an inverse-taper leading-edge flap on the aerodynamic characteristics in pitch of a wing-body combination having an aspect ratio of 3 and 45° of sweepback at Mach numbers to 0.92, *NACA TN* 4366, 10 pp. + 2 tables + 21 figs., Aug. 1958.

An investigation has been conducted to determine the effectiveness of a leading-edge flap in improving primarily the drag characteristics of a sweptwing-body combination. With the flap deflected, the wing had a camber and twist distribution similar to that resulting from the incorporation of conical camber in the forward portion of a plane wing. Aerodynamic data were obtained for flap angles to 16° over a Mach number range of 0.25 to 0.92 at a Reynolds number of 3.2 million, and over a Reynolds number range of 3.2 to 15 million at a Mach number of 0.25. Lift-drag ratios are compared with those of a similar model incorporating conical camber.

From authors' summary

1417. Dmitriev, V. N., and Shashkov, A. G., Force effect of an air jet on a flapper in pneumatic and hydraulic control devices of the "nozzle-flapper" type (in Russian), *Avtomatika i Telemekhanika* **17**, 6, 559–569, June 1956.

1418. Shires, G. L., and Munns, G. E., The icing of compressor blades and their protection by surface heating, *Aero. Res. Counc. Lond. Rep. Mem.* 3041, 28 pp. + 6 tables + 22 figs., 1958.

Vibration and Wave Motions in Fluids

(See Revs. 1221, 1361, 1579, 1586, 1617, 1618, 1619, 1620, 1621, 1623, 1624, 1625, 1626, 1627, 1629)

Fluid Machinery

(See also Revs. 1207, 1375, 1457, 1466, 1588)

1419. Grabow, G., Starting phenomena in pumps (in German), *Maschinenbau-Technik* **6**, 11, 621–627, Nov. 1957.

The problem of priming a water pump situated above the water level is treated. The Bernoulli equation for the time-dependent flow in the suction duct is derived for no friction and for friction. Assuming that the pump compresses a constant rate of volume of air, the movement of the water surface in the suction duct is calculated and compared for various assumptions: (a) no friction, (b) friction, but no inertia, (c) inertia and linear friction, and (d) inertia and friction proportional to the square of the velocity.

H. P. Eichenberger, USA

1420. van Niekerk, C. G., Ducted fan design theory, *J. Appl. Mech.* **25,** 3, 325–331, Sept. 1958.

A theory is outlined by means of which it is possible to design ducted fans directly and without having to choose any parameters in an arbitrary fashion. Optimum sizes and fan speeds are theoretically determined. The design of two fans, one having inlet guide vanes and the other of the low slip-stream-rotation type having NPL straighteners and often used in wind tunnels, is considered by way of example. While achieving a considerable degree of rationality, the theory introduces a concept of annulus efficiency that is still of an empirical nature. The empiricism is due to a present lack of knowledge about three-dimensional fan losses, and suggests further investigation.

From author's summary

1421. Veselov, A. I., Means of increasing the efficiency of centrifugal mine fans (in Russian), *Trudi i Materialy Sverdl. Gorn. In-ta* no. 26, 168–176, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6541.

1422. Emery, J. C., and Howard, P. W., Performance at low speeds of compressor rotors having low-cambered NACA 65-series blades with high inlet angles and low solidities, *NACA TN* 4344, 7 pp. + 15 figs., Aug. 1958.

Tests were made on three blades at solidities of 0.5, 0.75, and 1.0, without guide vanes or stators, over ranges of blade-setting angles and quantity-flow rates. The performance measured in these tests is compared with performance estimated from two-dimensional cascade data for the purpose of extending the correlation of cascade and compressor-rotor data over a range of high-inlet-angle conditions.

From authors' summary

1423. Conrad, O., Flow in axial compressor with 50% reaction (in German), *Motortech. Z.* **19,** 8, 285–287, Aug. 1958.

The radial distribution of axial velocity between rotor and stator is calculated for the normal stage of axial-flow compressors with 50% reaction, radially constant energy supply and mean radially constant axial ratios, adiabatic heads and radii. An incompressible axially symmetrical flow, free from losses, is assumed.

From author's summary

1424. Horlock, J. H., Some actuator-disc theories for the flow of air through an axial turbomachine, *Aero. Res. Counc. Lond. Rep. Mem.* 3030, 22 pp. + 17 figs., 1958.

Simplified methods are given for solution of the direct problem of the incompressible flow of air through an axial-flow turbomachine. General methods are given for (1) isolated actuator-disks (i.e. for machines with blade spacing such that aerodynamic interference may be neglected), and (2) actuator disks closely spaced.

The actuator disks may be placed in the plane of the trailing edges of the blades or at the blade centers of pressure. The methods by which the disks are placed in the plane of the trailing edges of the blades may not be as accurate as other methods.

J. Polasek, Czechoslovakia

1425. Jaumotte, A., Determination of rotational speed of abrupt rotating stall in axial flow rotors (in French), *C. R. Acad. Sci., Paris* **245,** 6, 631–634, Aug. 1957.

A simple formula is given connecting the rotational speed of sudden rotating stall with the flow characteristics at the outer radius of the rotor. It is obtained by equating the pressure at the outer radius of the stall zone, considered as a centrifugal compressor at no flow, with the pressure at the same radius given by the unstalled flow. Results from two rotors of very different design and performance yield correlating results. Attention is drawn to an apparent printing error in the analytical development; in the second equation from the bottom on p. 633 of the article, the denominator of the right-hand side should be ωr rather than ω^2.

D. G. Shepherd, USA

1426. Uvarov, V. V., Calculation of a centrifugal compressor having an air turbine (in Russian), *Sb. Statei Mosk. Vyssh. Tekh. Uch-shcha* **39,** 5–14, 1955; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4143.

1427. Zavadovskii, A. M., Flow through radial clearance of a turbine stage (in Russian), *Teploenergetika* **4,** 1, 8–12, Jan. 1957.

1428. Slisskii, S. M., Laboratory hydraulic and energy investigations of turbine installations at the Molotov, Knibyshevsk and Stalingrad hydroelectric stations. 1. Review of the investigations, carried out in MEI named V. M. Molotov and other organizations (in Russian), *Trudi Mosk. Energ. In-ta* no. 19, 106–109, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5572.

1429. Kovalenko, A. D., Stresses and displacements in turbomachine disks in combination with gyroscopic forces (in Russian), Vibration in turbomachines, Moscow, Akad. Nauk SSSR, 1956, 159–178; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6127.

The disk is examined in a movement which appears as the result of two rotations round a mutually perpendicular axis; it is assumed that the angular speeds of the transmitting and relative rotations are constant. In consequence of the action of disturbing Coriolis forces in such a movement, constrained oscillations of the disks appear. For a disk of constant thickness an accurate solution for the equation of motion is obtained in cylindrical functions; for a conical one, in converging stepped series. It is shown that in calculations for deflection the inertia forces appearing when the disk oscillates can be disregarded if the frequency of the disk's natural vibrations differs from the frequency of the disturbing Coriolis forces. The disk of constant thickness in this case is examined as a round plate, subjected to a load, changing in a radial direction in accordance with the linear principle; when the disk is of variable thickness the theory of calculations for round plates of variable section with one nodal diameter is used. An accurate solution is given in hypergeometrical functions of the problem on the unsymmetrical (with one nodal diameter) deflection of round plates with flexibility changing in a radial direction, according to the power principle. The deflection of a disk of conical outline is studied, and an investigation made of the constrained oscillations of a disk of constant section.

P. Ya. Konovalov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1430. Voitashevskii, D. A., Circular grid made of plates and the distributor of a hydroturbine (in Russian), *Trudi Vses. N.-I. In-ta Gidromashinostr.* no. 19, 20–33, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5516.

A method is worked out for calculating the flow around round grids, based on the conforming reflection of one period of the round lattice on the unitary round of the grid with a section $b < 1$ along the material axis. For the construction of the reflecting function, author adopts a method previously developed by him. It was shown that the deflection of the flow in a round radial lattice decreases in comparison with a straight lattice. Connected with this observation it was noted that the lack of accuracy in the calculation of the circulation for dense round lattices with solid outline, carried out by the formula $\frac{l2}{Q} = -tg\,\alpha$, decreased, as the influence of solidity leads to the increase of the deflection of the flow by the lattice (l_2 is the circulation at the outlet from the lattice, Q the discharge, α the angle read off from the bisection

of the angle of the outlet edge of the profile). More accurate formulas are adduced for the calculation of the mean circulation in straight and round lattices, taking into account the solidity of the profiles. The agreement of the calculated values for the circulation with the experimental, for dense lattices, was eminently satisfactory. All the values essential for the calculation of a round lattice made from 24 plates of the radial directing apparatus were incorporated in a nomograph. With some approximations the method is applicable for other numbers of vanes. The paper gives an example of the calculations. M. I. Zhukovskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1431. Alekseeva, R. N., Liakhovitskii, I. D., and Rzheznikov, Iu. V., Method for testing and profiling relatively short turbine blades (in Russian), *Teploenergetika* **3,** 6, 51-56, June 1956.

1432. Johnson, A. E., A means of improving the static performance of cruise-designed shrouded propellers, *J. Aero/Space Sci.* **25,** 8, 522-523 (Readers' Forum), Aug. 1958.

1433. Pivko, S., On a subsonic compressibility correction for propellers and rotors, *J. Aero. Sci.* **25,** 6, 395-396 (Readers' Forum), June 1958.

1434. Fujie, K., Three-dimensional investigation of flow in centrifugal impeller with straight radial blades, *Bull. JSME* **1,** 1, 42-49, Jan. 1958.

The flow through the passage of rotating impellers with single and double shrouds (full shrouds) has been studied experimentally by means of a test rig, so designed that it is possible to measure directly the relative velocity, flow direction, total and static pressure on several points in the passage while the impeller is rotating.

On the other hand, the theoretical analysis was made under the assumption of two-dimensional potential flow, and the calculated results are compared with the measured results in terms of relative velocity under the given operating conditions.

The velocity distribution and the flow direction obtained in the experiments indicate that secondary flows in the boundary layer tend to shift the low-energy air toward the negative surface (suction surface) of the blade in the passage. In case of single shrouded impeller, there is observed a counter effect along the casing surface apparently caused by the leakage through the clearance space between the blade and the casing. This results in a vortex flow in the passage. It can be concluded that the secondary flows consequently dominate the flow condition, and make it so complicated that it is impossible to conjecture it by means of theory. From author's summary

1435. Tachmindji, A. J., Morgan, W. B., Miller, M. L., and Hecker, R., The design and performance of supercavitating propellers, *David W. Taylor Mod. Basin Rep.* C-807, 33 pp., Feb. 1957.

A design method for supercavitating propellers is outlined and results of a number of tests are presented. Evaluation of the results shows that supercavitating propellers are feasible as a propulsion device for high-speed craft.

From authors' summary

1436. Maynard, J. D., and Salters, L. B., Jr., Aerodynamic characteristics at high speeds of related full-scale propellers having different blade-section cambers, *NACA Rep.* 1309, 5 pp. + 22 figs., 1957.

Comparisons are made of results obtained in wind-tunnel tests of related full-scale propellers over a range of blade angles from 20° to 55° at airspeeds up to 500 miles per hour to evaluate the combined effects of blade-section camber and compressibility on propeller aerodynamic characteristics.

From authors' summary

1437. Stellmach, I. Ya., An investigation of the blade distortion of a ship's screw propeller by means of electric strain gauges (in Russian), *Leningr. In-ta Inzh. Vod. Transp.* no. 23, 132-137, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 7271.

The purpose of the investigation was the measurement in natural conditions of the distortion of the blades of a bronze screw propeller in the experimental launch of the LIIVT.

The distortion of the screw propeller and propeller shaft was measured by means of electric strain gages of constantan wire. The strain gage leads were passed through the bored propeller shaft. The readings were recorded on an oscillograph film.

The tests were made under moored (dock) conditions, whereby the tow-rope pull, propeller speed and shaft horsepower were also measured.

The experimental method is described and the results discussed.

I. V. Girs

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Flow and Flight Test Techniques and Measurements

(See also Revs. 1369, 1377)

1438. Knapp, G. P., Force-balance pressure-measuring sensors, ASME-ARS Joint Aviation Conf., Dallas, Texas, Mar. 1958. Pap. 58-AV-18, 7 pp.

Force-balance pressure sensors appear to be the immediate answer to the requirement for accurate measurement of pressure altitude, Mach number, and other related quantities. Transducers built around these sensors are performing to accuracies of ¼% of altitude and 1% of Mach number or better, up to 80,000 ft altitude and Mach 3. The fact that these devices were only a gleam in the eye of the designer five years ago gives promise that further intensive development will produce even better performance.

From author's summary

1439. Mabey, D. G., The calibration at transonic speeds of a Mk 9A pitot static head with and without flow through static slots, *Aero. Res. Counc. Lond. Curr. Pap.* 384, 13 pp. + 1 table + 13 figs., 1958.

The static pressure error of a standard Mark 9A pitot static head at transonic speeds has been measured in the R.A.E. (Bedford) 3-ft tunnel. The static error may be reduced slightly by sealing the drain hole.

The effects of both flow through the drain hole and the rate of altitude change were simulated and for a typical aircraft system the static error corresponding with a high rate of descent was found to be small.

Some tunnel interference effects have been observed.

From author's summary

1440. Akeley, L. T., Batchelder, L. A., and Cleveland, D. S., Gyro-integrating mass flowmeter, *Trans. ASME* **80,** 8, 1849-1854, Nov. 1958.

Paper describes an integrating mass flowmeter designed for high-pressure natural-gas metering. The meter described provides direct reading of pounds of gas on a cylcometer register as well as electrical contacts for remote telemetering mass flow. No electronic elements are used in the design. A three-axis gyroscope is

used for integrating. The meter is designed for 1% integrating accuracy over 30 to 100% of rated flow. It operates over a 20-to-1 flow range. From authors' summary

1441. Itaya, S., and Takenaka, T., Flow measurement by means of inlet nozzles, *Bull. JSME* **1**, 1, 64–68, Jan. 1958.

Authors determined experimentally the discharge coefficients *c* of inlet nozzles, whose diameters range from one inch to 10.6 inches to measure air, water and oil flow quantity.

Experimental formula of *c* correlated to Reynolds number coincides with the experimental results.

From authors' summary

1442. Ibrahim, A. A. K., A new approach to the theory of an oscillating cylinder viscometer by dimensional analysis (in English), *ZAMP* **9**, 1, 74–77, Jan. 1958.

1443. Chistyakov, Yu. D., Golubtsov, I. V., and Priselkov, Yu. A., Transmitter for recording the torsion-vibration movements of the float of a viscosimeter (in Russian), *Zavod. Lab.* **22**, 7, 876–877, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5202.

1444. Beerbower, A., Controlling fluid processes with continuous viscometers, *Control Engng.* **5**, 6, 107–114, June 1958.

1445. Ibrahim, A. A. K., A method for measuring the dynamic viscosity and dynamic rigidity of visco-elastic liquids, I, *J. Phys. Soc. Japan* **13**, 3, p. 313, Mar. 1958.

1446. Winter, E. F., Flow visualisation techniques applied to combustion problems, *J. Roy. Aero. Soc.* **62**, 568, 268–276, Apr. 1958.

1447. Kirby, D. A., and Spence, A., Low-speed-tunnel model tests on the flow structure behind a delta-wing aircraft and a 40 deg swept-wing aircraft at high incidences, *Aero. Res. Counc. Lond. Rep. Mem.* 3078, 7 pp. + 3 tables + 9 figs., 1958.

In view of the possibility of trimming some swept-wing aircraft at incidences above the stall, there has been a desire to visualize the whole pattern of vortex sheets and separated flow starting from the stalling wing, and to follow it back beyond the tailplane. To supplement other methods, a swivelling head has been used, giving the velocity, pitch and yaw, and results are given in this report for a 48-deg delta (*Javelin*) and a 40-deg swept-wing aircraft (*Swift* without fences).

The tests showed that at incidences beyond the stall there is a large bubble of separated flow behind the wing. For the delta at 35 deg this bubble had not closed at the station of the tailplane and extended over the whole of the region behind the wing.

The velocity and pressure field found in the separated flow resembles that behind a square plate at 90 deg. The vorticity pattern, measured in a plane cutting the bubble of separated flow from the stalled wings, is complicated by rotating masses of air inside the bubbles, between the strong inner vortex sheets, and the weaker tip vortices.

The results have been analyzed to show the effect of change of tail height. From authors' summary

1448. Lockwood, V. E., and Vogler, R. D., Exploratory wind-tunnel investigation at high subsonic and transonic speeds of jet flaps on unswept rectangular wings, *NACA TN* 4353, 9 pp. + 20 figs., Aug. 1958.

The investigation was conducted on an unswept rectangular NACA 65A006 wing with an aspect ratio of 3.33 and a much thicker wing of the same planform which were modified at the trailing edges to provide several jet-flap configurations. Most of the data were obtained at an angle of attack of 0°. Lift, drag, and pitching-moment data are presented for a momentum-coefficient range varying from 0.30 at a Mach number of 0.40 to 0.03 at a Mach number of 1.10. From authors' summary

1449. McDevitt, J. B., and Taylor, R. A., Force and pressure measurements at transonic speeds for several bodies having elliptical cross sections, *NACA TN* 4362, 7 pp. + 1 table + 30 figs., Sept. 1958.

The measured forces and static-pressure distributions at the body surface and in the surrounding flow field are presented. All of the bodies had an axial distribution of cross-sectional area equal to that for a parabolic-arc body of revolution having a fineness ratio of 12. The bodies were tested through an angle-of-attack range from 0° to 6° and through a Mach number range from 0.80 to 1.20. From authors' summary

1450. Spiegel, J. M., Tunnell, P. J., and Wilson, W. S., Measurements of the effects of wall outflow and porosity on wave attenuation in a transonic wind tunnel with perforated walls, *NACA TN* 4360, 8 pp. + 15 figs., Aug. 1958.

Various wind-tunnel perforated-wall configurations were tested in the transonic speed range to evaluate the effects of wall outflow and wall porosity on the wave reflection on various models in the test section. The maximum outflow was 9.5% of the total mass flow and the porosity was varied from 0.60 to 24.4% open.

From authors' summary

1451. Graham, R. W., Guentert, Eleanor C., and Huff, V. N., A Mach 4 rocket-powered supersonic tunnel using ammonia-oxygen as working fluid, *NACA TN* 4325, 15 pp. + 23 figs., Sept. 1958.

To simulate the high heating rates encountered in hypersonic flow, the exhaust gases from an ammonia-oxygen rocket have been used to power a supersonic tunnel. A gas temperature of 4500 R at Mach 4 was produced in the 15-in. test section of the tunnel.

The calibration pressure data indicate reproducibility of test conditions in this facility. Physical, transport, and one-dimensional aerodynamic data for combustion products of ammonia and oxygen are included. From authors' summary

1452. Dayman, B., Jr., Blocking in the supersonic wind tunnel, *J. Aero. Sci.* **25**, 4, 264–265 (Readers' Forum), Apr. 1958.

1453. Johnson, R. H., Asymmetric starting for hypersonic wind tunnels, *J. Aero. Sci.* **25**, 5, 341–342 (Readers' Forum), May 1958.

1454. Miyahara, Y., and Richardson, E. G., Ultrasonic relaxation and attenuation in freons, in relation to their use in supersonic wind tunnels, *Aero. Res. Counc. Lond. Curr. Pap.* 356, 19 pp. + 11 figs., 1957.

From the point of view of their use in supersonic wind tunnels in which it is desired to obtain a high Mach number without great expenditure of power, the substitution of the air by vapors having a low velocity of sound is of interest. The freons (halogen-substituted methanes) suggest themselves for this. It is shown that these vapors have ultrasonic relaxation times in the neighbourhood of 10^{-7} sec coupled with high-absorption coefficients in the ultrasonic range. Though this may limit their usefulness when comparison with the forces on bodies in the atmosphere near sea level is desired, the relaxation effects may be useful to similate conditions at high altitudes.

It is shown that admixture of air, up to 10%, does not change the relaxation time for the absorption coefficient in freon.

To obtain a ratio of specific heat to correspond to that of air at sea level, a rare gas may be added to the freon, but the velocity of sound in the mixture is thereby raised and some of the advantage in Mach number lost. From authors' summary

1455. Chinneck, A., Berry, C. J., and Peggs, P. J., Tests on a two-dimensional slotted-wall wind tunnel with lateral obstructions behind the slots, *Aero. Res. Counc. Lond. Curr. Pap.* 372, 7 pp. + 27 figs., 1958.

1456. Rainey, A. G., Measurement of aerodynamic forces for various mean angles of attack on an airfoil oscillating in bending with emphasis on damping in the stall, *NACA Rep.* 1305, 33 pp., 1957.

The oscillating air forces on a two-dimensional wing oscillating in pitch about the midchord have been measured at various angles of attack and at Mach numbers of 0.35 and 0.7. Large regions of unstable damping in pitch were found. Measurements of the aerodynamic damping of a 10-percent-thick and a 3-percent-thick finite-span wing oscillating in, essentially, the first bending mode indicate no regions of unstable damping for this type of motion over the range of variables covered.

From author's summary

1457. Shivers, J. P., and Carpenter, P. J., Effects of compressibility on rotor hovering performance and synthesized blade-section characteristics derived from measured rotor performance of blades having NACA 0015 airfoil tip sections, *NACA TN* 4356, 13 pp. + 14 figs., Sept. 1958.

An investigation has been conducted at the Langley helicopter test tower to determine the low tip Mach number blade maximum mean lift coefficient and high tip Mach number compressibility effects. Data are presented for blade tip Mach numbers from 0.27 to 0.81 and corresponding Reynolds numbers from 1.64×10^6 to 4.78×10^6. Synthesized rotor-blade section-lift and profile-drag-coefficient data derived from experimental data are presented and compared with previously obtained two-dimensional data.

From authors' summary

1458. Polhamus, E. C., Some factors affecting the variation of pitching moment with sideslip of aircraft configurations, *NACA TN* 4016, 22 pp. + 13 figs., Aug. 1958.

A brief study of available wind-tunnel data with regard to the variation of pitching moment with sideslip has been made. The results indicate that the effect of sideslip on the pitching moment can be large and is dependent upon a large number of factors. For example, it was found that wing planform, wing position, horizontal-tail location, aileron location, and fuselage shape can have appreciable effects on the pitching moment due to sideslip. However, data at large sideslip angles are rather meager and a considerable amount of systematic experimental data is needed, especially at transonic and supersonic speeds.

From author's summary

1459. Brook, J. W., An approximate method for determining the wave drag of axisymmetric conical cowls, *J. Aero. Sci.* **25**, 6, 401–402 (Readers' Forum), June 1958.

1460. Wight, K. C., Measurements of two-dimensional derivatives on a wing-aileron-tab system with a 1541 section aerofoil: Part II—Direct tab and cross aileron-tab derivatives, *Aero. Res. Counc. Lond. Rep. Mem.* 3029, 9 pp. + 22 tables + 20 figs., 1958.

Measurements have been made of the direct tab derivatives and cross aileron-tab derivatives for a 1541 section two-dimensional airfoil (N.P.L. 282) with a 20% aileron and 4% (approx.) tab. In addition, some measurements of the direct aileron derivatives have been made for comparison with earlier results together with a number of static derivatives for the wing and controls.

The influence is shown of frequency parameter, Reynolds number, position of transition, mean tab angle and sealing of the control hinge gaps. Some tests have been made with the aileron set at minus 8 deg and the tab at plus 12 deg for which condition the hinge moment on the aileron was zero.

Reasonable agreement with the values given by the "equivalent profile" theory is shown for both direct damping derivatives and for the direct tab stiffness derivative. The direct aileron stiffness derivative shows some departure from the theoretical value when $\omega > 1$.

At $\omega = 2$, $R = 10^6$ and the natural transition, comparison with the values given by flat-plate theory gives the following approximate factors, where suffix $_T$ denotes the theoretical values:

$$b_\beta/(b_\beta)_T = 0.6,\ b_\gamma/(b_\gamma)_T = 0.4,\ t_\beta/(t_\beta)_T = 0.5,\ t_\gamma/(t_\gamma)_T = 0.5,$$
$$b_{\dot\beta}/(b_{\dot\beta})_T = 0.6,\ b_{\dot\gamma}/(b_{\dot\gamma})_T = 0.5,\ t_{\dot\beta}/(t_{\dot\beta})_T = 0.5,\ t_{\dot\gamma}/(t_{\dot\gamma})_T = 0.5.$$

From author's summary

1461. Weber, J., and Brebner, G. G., Low-speed tests on 45° swept-back wings. Part I: Pressure measurements on wings of aspect ratio 5, *Aero. Res. Counc. Lond. Rep. Mem.* 2882, 6 pp. + 8 tables + 13 figs., 1958.

Report contains the results of pressure measurements on three 45-deg sweptback wings with constant chord and aspect ratio 5, over an incidence range up to 10 deg. Chordwise and spanwise lift distributions are given, mostly near the center where, on two of the wings, modifications had been made to the section shape. It was found that altering the thickness distribution in the center did not affect the loading but that approximately straight isobars could be obtained at values of C_L below about 0.1. By the incorporation of twist and camber in the central part, the distortion of the lift distribution in the center could be avoided at one particular incidence, and thus the same chordwise distribution obtained over most of the span.

Twist and camber alone do not improve the isobar pattern and therefore a thickness modification would be needed to give the desired lift distribution and isobar pattern at one particular incidence.

From authors' summary

1462. Pringle, G. E., and Harper, D. J., The spinning of model aircraft and the prediction of full-scale spin and recovery characteristics, *Aero. Res. Counc. Lond. Rep. Mem.* 2906, 104 pp., 1956.

Report discusses some technical aspects of a long series of tests made with dynamic scale model aircraft in the Royal Aircraft Establishment Vertical Tunnel for the purpose of studying their spinning characteristics. Data accumulated up to the end of 1947 are included, and mention is made, where appropriate, of any further work done up to the end of 1949. The central problem is that of drawing valid conclusions regarding the full-scale spin and recovery; with this in mind there is some discussion of the sensitivity of the spinning model to applied forces, including those that upset the spin to produce recovery and those that alternatively generate a new spin. The difference between model- and full-scale spins is analyzed with a view to correcting the model data, and some attention is given to power-on spins. A chapter is given to special aspects of the spin of tailless aircraft, and another to safety devices.

From authors' summary

1463. Edge, P. M., Jr., Hydrodynamic impact loads of a-20° dead-rise inverted-V model and comparisons with loads of a flat-bottom model, *NACA TN* 4339, 12 pp. + 2 tables + 18 figs., Aug. 1958.

Hydrodynamic-impact-loads data were obtained at the Langley impact basin from tests of a narrow-beam model. Fixed-trim impacts were made in smooth water over a range of landing conditions at a beam-loading coefficient of 19.15, with a few impacts at beam-loading coefficients of 27.90 and 36.07. Loads, moments, motions, and bottom pressures were measured throughout

each of the impacts. The maximum impact loads for the inverted-V model are compared with loads obtained for a flat-bottom model.

From author's summary

1464. Schexnayder, C. J., Jr., On the performance of a double-diaphragm shock tube using the reflected-shock method and a light-gas buffer, *J. Aero/Space Sci.* **25,** 8, 527–528 (Readers' Forum), Aug. 1958.

Thermodynamics

(See also Revs. 1215, 1265, 1397, 1559, 1597, 1598)

1465. Haase, R., The second law of thermodynamics and structuring in nature (in German), *Naturwissenschaften* **44,** 15, 409–415, Aug. 1957.

Philosophical in its contents the article would appear to be without direct, practical influence on engineering problems. Author maintains that, owing to the latest progress made in the field of thermodynamics, the Second Law of Thermodynamics may assist in the interpretation of some happenings in biological systems. He attempts to dispel doubts of the validity of the second law in the case of such biological, or natural, systems, doubts which, to the reviewer's knowledge, have been expressed by several Western European physicists and which may have lead to the gloomy term "Wärmetod" (heat-death).

In a purely qualitative exposé, author carefully defines terms like entropy; isolated, closed, and open systems; irreversible processes; entropy flow and entropy generation; steady-state condition of unbalance or stationary condition; and others. He refers to the statistical meaning of the second law à la Boltzmann. He mentions local entropy generation and its representation as the sum of products of generalized velocities or generalized currents and respective generalized affinities or generalized forces. Phenomenological coefficients are introduced following a basic idea by Onsager. Two appendices elaborate on the less familiar definitions. Fourteen references are listed.

From the author's summary the proper interpretation of the second law does not lead to uncomfortable contradictions (Wärmetod!), but promises fruitful cooperation between physical chemistry and biology. Reviewer does not feel qualified to comment on the novelty of the article.

H. Hegetschweiler, USA

1466. Dini, D., Theoretical investigation of the fluid dynamics of "wave-engines" operating according to the principle of the "Comprex" (in Italian), *Aerotecnica* **38,** 1, 8–18, Feb. 1958.

Modern gasdynamics treats nonsteady gas flow to find new engine concepts which may possibly give better efficiencies than conventional engines. Among some applications of unsteady flow engines, the "Comprex" of Brown Boveri appeared to improve the efficiency of known thermodynamic cycles by introducing the utilization of shock-waves occurring when the steady air flow coming from compressor is stopped and then mixed with high pressure gases of combustion, before such mixture reenters the combustion chamber by a regenerative fan. The present theoretical investigation shows that the unsteady flow occurring in the Comprex is not a convenient arrangement for use with the steady cycle of compressor-turbine plants. Size, rotation speed of the rotor carrying the tubes where the unsteady process should take place, adjustment of the cycle phases, and the specific volume difference between air from compressor and gas from combustion which should exchange energy in such tubes, did not result in reasonable advantages from such compound engine.

From author's summary

Book—1467. Proceedings of the conference on thermodynamic and transport properties of fluids, London, Institution of Mechanical Engineers, 1958, viii + 219 pp.

This three-day conference on thermodynamic and transport properties of fluids held in London from July 10 to 12, 1957, was sponsored by the Institution of Mechanical Engineers and the International Union of Pure and Applied Chemistry. Thirty papers were presented by representatives from the United States, Great Britain, Canada, Belgium, France, Australia and the Soviet Union.

The first day of the meeting was devoted to *P-V-T* properties: an extension to the theory of corresponding states involving an acentric factor; the prediction of liquid-vapor equilibria of ternary mixtures from those of the binary mixtures of the components of the ternary system; the thermodynamic properties, viscosity and thermal conductivity of heavy water; the prediction of the thermodynamic properties of diatomic gases and their dissociation products from 5,000 to 25,000 K; measurements of ultrasonic propagation to determine c_p/c_v, thermodynamic functions near the critical point and other properties; practical problems in calibrating high-pressure balances; a method of determining the compressibility of industrial gas mixtures; the equation of state of nitrogen at high temperatures and pressures; thermodynamic properties of straight-chain saturated hydrocarbons and normal alcohols; the work of the U. S. Bureau of Standards and the American Petroleum Institute on the compilation of thermodynamic properties; a review of the thermodynamics of non-ideal gases.

The second day's topics were thermal conductivity, diffusivity and viscosity: the connection between intermolecular forces and transport properties; thermal conduction in gases with and without chemical reaction; viscosity at very low and very high temperatures; thermal conduction in liquids and compressed gases; enthalpy charts for combustion at liquid and solid fuel surfaces which simplify heat and mass transfer calculations; the thermal conductivity of methane; viscosities and thermal conductivities of ammonia, ethylene, nitrogen, carbon dioxide and argon.

The third day was devoted to thermal and electrical conductivity and thermal diffusion: thermal and electrical conductivities of molten metals; thermal diffusion in hydrogen-nitrogen mixtures; experimental methods of determining thermal conductivity and thermal diffusion constants.

Although this conference could naturally cover only a rather small portion of the work that is being carried on in this important field, it probably pictured quite accurately the nature of recent progress in experimental work, theory and data compilation. It served also to underline the growing importance of theoretical physics and chemistry to the mechanical and chemical engineering professions.

A. W. Gessner, USA

1468. Brokaw, R. S., Approximate formulas for the viscosity and thermal conductivity of gas mixtures, *J. Chem. Phys.* **29,** 2, 391–397, Aug. 1958.

Simple formulas for transport properties of gases are quite useful in practical fluid flow problems. Starting with kinetic theory equations which are valid to first order in a Sonine polynomial expansion for viscosity and to second order (neglecting thermal diffusion) in a Sonine polynomial expansion for thermal conductivity, author derives theoretically three different degrees of approximation to these coefficients for multi-component gas mixtures. Lowest-order approximation is shown to be of the same form as previously-existing simple semi-empirical correlations and to agree within 5% with exact theory and with experiments. Higher approximations agree more closely with rigorous theory; third approximation is exact for binary mixtures. The fact that the time required in computing second and third approximations is the same as that needed to calculate the coefficients rigorously reduces the practical utility of the higher-order results.

Assuming an abnormal interchange of translational energy in interactions between polar molecules, the thermal conductivities of binary mixtures of polar and nonpolar gases are computed in the second approximation and shown to be in excellent agreement with experiment. This agreement is obtained semi-empirically by adjusting a single parameter in the theoretical conductivity equation.

Reviewer believes that, while the new formulas are not of great practical value, author has made an important contribution in demonstrating the kinds of approximations which must be introduced into the rigorous theory in order to obtain conventional empirical viscosity and conductivity equations.

F. A. Williams, USA

1469. Bauer, E., and Zlotnick, M., Transport coefficients of air to 8000° K, AVCO Research and Development Division, RAD-TR-58-12, 67 pp., Sept. 1958.

The coefficients of viscosity and of frozen and reaction conductivity of air have been calculated for a temperature range 3000 $K < T < 8000$ K, and a density range $10^{-3} < \rho/\rho_0 < 10$, where ρ_0 is the density of air at 1 atmosphere pressure and $T = 273$ K. Authors use an intermolecular potential of form A/r^n where r = intermolecular distance and the exponent $n = 6, 8$. This form of the potential is fitted to data derived from Amdur's scattering experiments. A critical discussion of uncertainties in calculations of this kind and a comparison with earlier work are given in this report. The over-all accuracy of the transport coefficients obtained here is estimated as ± 25–30%. The effect of free electrons is considered in an appendix. From authors' summary

1470. Tsederberg, N. V., Thermal conductivity of oils (in Russian), *Teploenergetika* **4,** 2, 52–53, Feb. 1957.

1471. Tsederberg, N. V., and Timrot, D. L., Experimental determination of the thermal conductivity of liquid oxygen (in Russian), *Zh. Tekh. Fiz.* **26,** 8, 1849–1856, Aug. 1956.

1472. Plankenhorn, W. J., Evaluation of the thermal insulative characteristics of ceramic coatings, *Bull. Amer. Ceram. Soc.* **37,** 8, 366–369, Aug. 1958.

A differential thermocouple technique for evaluating the insulative characteristics of ceramic coatings is described. Data obtained by this method show that selected coatings which were essentially vitreous caused heat to penetrate the metal more rapidly than when there was no coating present. A coating containing a large percentage of refractory materials and a minimum of glass had the reverse effect.

From author's summary

1473. Schrock, V. E., and Starkman, E. S., Spherical apparatus for measuring the thermal conductivity of liquids, *Rev. Sci. Instrum.* **29,** 7, 625–629, July 1958.

A thin-film spherical conduction apparatus was designed and constructed for application to relatively viscous liquids such as hydrocarbon lubricants over a temperature range from ambient to − 100 F and encompassing the solidification temperature. Freedom from the effects of convective heat transfer was demonstrated experimentally. The absolute accuracy of the measurements made with this instrument is believed to be within 2%.

From authors' summary by A. Levy, USA

1474. Parkinson, K. H., The specific heats of metals at low temperatures, Reports on Progress in Physics, **21,** London, The Physical Society, 226–270, 1958.

1475. Deissler, R. G., and Boegli, J. S., An investigation of effective thermal conductivities of powders in various gases, ASME Ann. Meet., New York, N. Y., Dec. 1957. Pap. 57-A-110, 7 pp.

Effective thermal conductivity of three powders in several gases was found to depend upon the conductivity of the gas and the solid material and upon porosity. A considerable temperature range was studied. Above a minimum called the breakway pressure, conductivity did not depend upon pressure. This breakway pressure was correlated in terms of a critical Knudsen number.

Reviewer feels certain aspects are not adequately explained: (1) Difference in *K-t* relationship in Figs. 5a and 5b. (2) Some data on individual solid-gas combinations appear to give different characteristics than over-all trend implied in Fig. 8. (3) Use of only two different porosities for each solid makes isolation of porosity from some shape-factor effect questionable.

G. M. Ketchum, USA

1476. Zavaritskii, N. V., and Zel'dovich, A. G., Heat conductivity of commercial materials at low temperatures (in Russian), *Zh. Tekh. Fiz.* **26,** 9, 2032–2036, Sept. 1956.

1477. Kontorova, T. A., Thermal expansion and heat conductivity of some crystals (in Russian), *Zh. Tekh. Fiz.* **26,** 9, 2021–2031, Sept. 1956.

1478. Gel'd, P. V., and Kuprovskii, B. B., and Serebrennikov, N. N., Thermal conductivity of steels at elevated temperatures (in Russian), *Teploenergetika* **3,** 6, 45–51, June 1956.

1479. Gilbert, R., On the relations of thermodynamics of irreversible transformations and the conditions of their validity (in French), *C. R. Acad. Sci., Paris* **245,** 19, 1602–1604, Nov. 1957.

Article presents proof of Onsager's reciprocal relations and a generalization thereof on the basis of classical thermodynamics and an hypothesis about entropy-production.

P. E. Kriezis, Greece

Book—1480. Hausen, H., (edited by Plank, R.), Handbook of refrigeration: Production of very low temperatures, gas liquefaction, and separation of gas mixtures [Handbuch der Kaltetechnik: Erzeugung Sehr Tiefer Temperaturen, Gasverflussigung und zerlegung von Gasgemischen], Berlin, Springer-Verlag, 1957, xii + 412 pp. DM 72.

Author, Professor at the Institute of Technology in Hannover, has the best background to address himself with authority to the technicians in his branch since he has been with Lindes Eisenmaschinen AG, Liquified Gas Machine Department, for 28 years.

The first 272 pages of his book deal with the theory for condensation processes and distillation of the condensate The next 125 pages give a constructive description of the machinery equipment and the use of gases produced according to the low-temperature method. The book is not loaded with ample theories. Clear diagrams showing the thermal properties of air, methane, nitrogen, hydrogen and helium are given. The theoretical minimum work for condensation of gas according to Gouy's and Stodola's law and also the Thomson-Joule effect are dealt with on some pages which also contain some thermodynamic expressions. Author describes how to derive the absolute temperature from temperature values measured according to other scales, and how to reach as low a temperature as 0.000015 K by demagnetizing salts and affecting the magnetic moment of the atomic nucleus. The theoretical output of liquified gas processes is thoroughly dealt with on 45 pages, and 60 pages are devoted to the theories for distillation and for rectifiers. The distillation of oxygen and nitrogen in the air as well as the production of rare gases are thoroughly described on 70 pages. After that follow the theories for heat exchangers and regenerators.

The last part of the book contains construction and running data which are elucidated by very detailed drawings. The most interesting subject dealt with is perhaps the construction of heat exchangers and expansion turbines. The construction of transport

vessels and the properties of various materials at low temperatures are also specified. It can be seen from the above that the book is of extremely great value for those technicians who have to do with refrigeration at low temperatures.

M. Backstrom, Sweden

1481. Rozenfel'd, L. M., and Onosovskii, V. V., and Serdakov, G. S., Experimental testing of the feasibility of adapting refrigerating machinery for heating and cooling buildings using heat produced in the operation of hydroelectric power stations (in Russian), *Zh. Tekh. Fiz.* **26**, 9, 2037–2045, Sept. 1956.

1482. Malmquist, L., Sorption as deformation of space (in English), *Kyltekn. Tidskr.* **17**, 4, 49–57, Aug. 1958.

The process of sorption has been studied previously in such a way that, on the basis of reasonable assumptions, isotherms have been derived which, when compared with experimental data, have given more or less probability to the correctness of the assumptions. The problem has been attacked in a quite different manner in this paper. Starting from two principles of most general character, the isothermal sorption equilibrium has been derived, using no other assumptions in the theory. The first principle is that matter is concentrated in mass units; the second is a new principle called the "principle of deformation of space." This theory, if correct, has the power of giving information of the physical events during sorption, and the difficulties in its applications arise in the physical interpretation of the predictions of the theory.

The preliminary application of the theory, made in this paper, seems to indicate that the theory is correct, though wrong conclusions may have been drawn in some details. A further application in terms of experiments with special reference to the theory must be performed before the correctness can be definitely proved.

The theory, being based on a general interaction process between molecules, seems to be applicable to other processes than sorption, e. g., on solutions and perhaps on a general equation of state.

From author's summary

Book—1483. Wolfe, H. C. (edited by), Temperature. II. Its measurement and control in science and industry, New York, Reinhold Publishing Corp., 1955, x + 467 pp. $12.

This well-integrated collection of papers was presented at the Third Symposium on Temperature in Washington, D. C., October 1954. One is tempted to compare this book with Vol. I (deriving from a similar conference in 1939), but except for the fact that the influence of Vol. I is strongly felt in the papers, this book stands alone. Whereas it is not a detailed handbook, it serves as an admirable reference, clarifying and bringing together the approaches to definition of temperature, and dealing penetratingly with the problems of standards and the technical limitations of precise measurement. Widely different approaches to temperature problems are dovetailed together in such a way as to provide rich stimulation for the student.

In the section on *General Concepts* the macroscopic thermodynamic basis for temperature is introduced by Hugh C. Wolf. F. E. Simon continues with the microscopic concept in the low temperature range where degrees of freedom are beginning to vanish, (negative temperature is introduced). High gas temperatures are dealt with by G. H. Dieke, taking account of spectral effects, ionization, and the doppler broadening of spectral bands, among other factors. Cecilia Payne-Gaposchkin deals with astrophysical temperatures, giving a wealth of data and nearly 100 references.

In the section on *Standards and Scales,* J. A. Beattie supplies the best reference this reviewer has seen on gas thermometry. This is supplemented by a short note on helium between 2 and 4 K, by W. E. Keller. Helmut Moser continues with a discussion of high-temperature gas thermometry, stressing ways and means. Though the international temper[illegible]ture scale has been repeatedly referred to in the preceding pape[illegible] [illegible]iscerningly dealt with by J. A. Hall, who provides a reference which should be of considerable value to students. H. F. Stimson strengthens this discussion with a completely independent chapter on fixed points, shedding considerable light on present limits of precision. H. Preston-Thomas continues with a chapter on the Zinc point.

Interest returns to the low temperature range where R. B. Scott writes about scales in the range from 90 to 5 K; R. P. Hudson discusses the helium vapor pressure scale; and H. van Dijk treats on techniques of magnetic thermometry.

In the section on *Transient Phenomena* we find two papers: an introduction to the thermodynamics of irreversible processes and fluctuations by I. Prigogine, and K. F. Herzfeld's discussion of relaxation of partial temperatures.

In the section on *Experimental Measurements* we find "Thermometry below 1 K" by D. de Klerk and "Experimental temperature measurements in flames and hot gases" by J. P. Broida; H. J. Hoge assesses "Temperature measurement in engineering;" J. G. Daunt deals exhaustively with "Superconductors as thermometers;" S. A. Friedberg discusses "Semiconductors as thermometers," and A. L. Hedrich with D. R. Pardue discusses thermometric use of sound velocity.

In the section on *Miscellaneous Topics,* we find "Temperatures in atomic explosions" by F. G. Brickwedde; "Ionization measurements at high temperatures" by W. Lochte-Holtgreven; and "Temperatures in the upper atmosphere" by H. E. Newell, Jr.

In view of such varied topics the book has a surprising unity, and actually makes interesting armchair reading. There are a sufficient number of major articles, reinforced by appearance in related groups, to assure that this book will become a lasting reference on the subject of temperature.

R. A. Burton, USA

1484. Lochte-Holtgreven, W., Production and measurement of high temperatures, Reports on Progress in Physics, **21,** London, The Physical Society, 1958, 312–383.

Author's abstract serves well to indicate the scope of the review and the relative emphasis accorded his wide selection of topics. The relevant statements read as follows: "The article is based mainly upon the study of thermally excited plasmas with temperatures in the range of 10,000–70,000 K. In case of no self-absorption the measurement of these temperatures can be effected by observation of lines or of continuous radiation emitted from the plasma. The study of lines implied both line intensities and line shapes. Following the discussion of the different methods of evaluating temperatures the specific properties of a plasma—viscosity, electrical and heat conductivity—are touched upon.

"Sections 2 to 6 deal with the production of high temperatures. Arcs, pulsed discharges and sparks, exploding wires and shock waves, and finally chemical reactions are discussed. The temperatures actually obtained, the practical applications, and the limitations of the different approaches are indicated."

This survey constitutes a useful qualitative introduction to high-temperature physics. The sections dealing with shock waves and chemical reactions are sketchy and contain an incomplete selection of references.

S. S. Penner, USA

1485. Stow, R. W., Rapid high-sensitivity recording thermometer, *Rev. Sci. Instrum.* **29**, 9, 774–775, Sept. 1958.

Paper describes a rapid high-sensitivity thermistor thermometer including the circuit details for the activation of the thermistor bridge circuit and associated amplifier. Using a small bead thermistor housed in a hypodermic needle, the 95% response time is about 0.17 sec, and noise levels as low as 2×10^{-4} C have been obtained.

From author's summary

1486. Werner, F. D., Total temperature measurements, ASME-ARS Joint Aviation Conf., Dallas, Tex., Mar. 1958. Pap. 58-AV-17, 12 pp.

The history of the development of total temperature probes is reviewed briefly, starting with the diffuser probe developed by Franz and including various simplifications and refinements of this type of probe. The other probe types described are a simplified type which omits the diffuser, types in which heat-conduction errors are suppressed, types which include radiation shields, and de-iced types. One of these designs having almost negligible conduction errors, no diffuser, and radiation shields, which is identified as the MA-1 probe, is described in considerable detail, since a great deal of information exists on its recovery errors, radiation errors, time constant, self-heating effect, angle of attack sensitivity, drag, and calibration accuracy. Where possible it is compared with the other total temperature probe types. An example is given of a complete error analysis for this probe. The various considerations involved for proper installation are outlined. From author's summary

1487. Kuklin, L. G., Measuring the surface layer temperature of workpieces machined on milling machines (in Russian), *Vestnik Mash.* **37,** 3, 46–48, Mar. 1957.

1488. Harman, T. C., Multiple stage thermoelectric generation of power, *J. Appl. Phys.* **29,** 10, 1471–1472, Oct. 1958.

The efficiency equation for any number of thermoelectric generators thermally in series is derived. The design relationships for maximum efficiency and for maximum power transfer of a multiple-stage thermoelectric generator are also given. Since the efficiencies are approximately additive, an appreciable increase in generator efficiency is anticipated by use of multiple stages.

From author's summary

1489. Mochan, S. I., Permissible error in rating air temperature (in Russian), *Teploenergetika* **4,** 1, p. 54, Jan. 1957.

1490. Deissler, R. G., and Perlmutter, M., An analysis of the energy separation in laminar and turbulent compressible vortex flows, Heat Transf. and Fluid Mech. Inst., Univ. of Calif.,Berkeley, Berkeley, Calif., June 1958, 40–53.

The problem occurs, for instance, in connection with the Ranque-Hilsch vortex tube. The model considered is an axially symmetric vortex in which the tangential velocity and the temperature are independent of axial position. The tangential and radial velocities at a reference radius, and the axial mass velocity as a function of radius and axial position, are specified. The analysis indicated that in the laminar case the dimensionless tangential velocity and temperature distributions are functions of a radial flow Reynolds number, the ratio of axial flow out of the core of the vortex to that out of the whole vortex, and the ratio of the radius of the core to the radius of the vortex. For the turbulent case the Reynolds number was replaced by an equivalent turbulent Reynolds number in which the turbulent viscosity took the place of the viscosity.

In the laminar case the energy separation was greatest at low Reynolds numbers and became negligibly small at the higher Reynolds numbers usually attained in experiments. In actual vortex tubes, the effect of turbulence is twofold: First, it causes the effective Reynolds number to remain low (where energy separation can take place), even when the laminar Reynolds number is high. This is because turbulent viscosity may be several orders of magnitude higher than the viscosity. Second, there is an additional energy separation in the turbulent case due to the expansion and contraction of the eddies as they move radially in a pressure gradient. The predicted curves for over-all energy separation closely resembled experimental curves, so that it appears that the model analyzed here displays most of the features of actual vortex tubes.

From authors' summary by J. C. Rotta, Germany

1491. Westley, R., Vortex tube performance data sheets, *Coll. Aero. Cranfield Note* 67, 7 pp. + 65 figs., July 1957.

Experiments to determine the effect of various operating and design parameters on the performance of a vortex tube are described in *Coll. Aero. Note* no. 30. The present note gives additional performance data on this tube and should be used as a supplement to *Note* 30.

These data sheets are intended as an aid to the estimation of the performance of vortex tubes and to the design of vortex tubes with given characteristics. In particular, the present note provides the optimum values of the vortex tube parameters which give maximum temperature drops.

Figures 12–53 give temperature-drop and cold-mass-flow ratio characteristics, figures 54–61 give the cold-mass-flow ratios at maximum temperature drop, while figures 62–65 give the optimum inlet and cold outlet sizes for maximum temperature drop.

From author's summary

Heat and Mass Transfer

(See also Revs. 1265, 1378, 1381, 1472, 1473, 1476, 1478, 1480, 1481, 1482, 1483, 1484, 1487, 1488, 1489, 1490, 1491, 1540, 1541, 1542, 1550, 1558, 1581, 1595)

Book—1492. Brunst, W., Inductive heat treatment [Die induktive Wärmebehandlung], Berlin, Springer Verlag, 1957, xii + 240 pp. DM 43.50.

Inductive heat treatment enables the highest energy transfer to the piece of work, some 10,000 Watts/cm² compared with 1000 Watts/cm² with gas flame. The growing use of inductive heat treatment in manufacturing processes induced the publishing of a complete reference work which will fill a need in the German technical literature. Beginning with the principles of induction heating, a comparison is given of the influence of different frequency ranges on the heating effect. The over-all thermal efficiency in the three principal frequency ranges (50–60 c, 500–10,000 c, and $10^5 - 2 \times 10^6$ c) can be estimated as 75:60:37.5. The corresponding costs in marks/KW are given as 400–200 for low frequency, 800–1000 for M.F. and 6000–1200 for H.F. Obviously the lowest possible frequency should always be chosen with regard to the physical and manufacturing conditions.

Section II.A analyzes the electrical equations of the induction law, magnetic fields, inductivity, counterinductivity, and gives valuable graphs for determining these values. Other sections discuss the theory of axial current flow in cylindrical conductors, plates, their heating equations and the vector diagrams of transformers used for induction heating, and the thermodynamical principles of the induction heating process.

Section IV reports practical solutions of induction heating devices; section V discusses the motor generators for middle frequency, and the tube generators to be used for high frequencies over 1 mc. Section VI comments on the economic problems of induction heat treatment. In Section VII the surface-hardening of steel is discussed with the *T-T-T* (Time-Temperature-Transformation) diagrams. An extensive bibliography and many graphs complete the text.

The entire work is excellent in its logical design and its useful examples, and can be recommended to every engineer interested in this field. A. Lenkey, USA

1493. Kraus, A. D., The use of steady-state electrical network analysis in solving heat flow problems, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-14, 15 pp.

Instead of solving heat-flow problems by taking measurements in steady-state electrical networks, it is frequently possible to solve such problems by network analysis. The four methods of

analysis described are mesh or loop analysis, nodal analysis and the theorems of Thevenin and Norton. Reviewer believes that some of the methods will lead also to simplification in case of actual circuit measurements. V. Paschkis, USA

1494. Seide, P., On one-dimensional temperature distribution in two-layered slabs with contact resistance at the plane of contact, *J. Aero/Space Sci.* **25,** 8, 523-524 (Readers' Forum), Aug. 1958.

A general solution was developed for both the steady-state and transient state. The actual value of the specific contact resistance still remains as the dominant yet indeterminate variable.

W. L. Sibbitt, USA

1495. Philippova, L. A., Unsteady motion of a viscous incompressible fluid in a narrow slit of constant breadth in the presence of heat transfer (in Russian), *Vestnik Leningrad Univ.* **12,** 1, 141-151 and 210-211, 1957.

A problem in viscous flow with heat conduction and energy dissipation under conditions where convective effects may be neglected is examined under the assumption of constant fluid properties, including density. The pressure gradient in the narrow two-dimensional slot is assumed to be time- and position-dependent. Heat is transferred to the walls by conduction. One wall is assumed to be stationary, with the other moving. Since the slot is narrow the results are applicable to annular regions as in the hydrodynamic theory of lubrication. Explicit formulations are given for the velocity and temperature distribution for arbitrary boundary conditions. N. A. Hall, USA

1496. Sparrow, E. M., The thermal boundary layer on a nonisothermal surface with non-uniform free stream velocity, *J. Fluid Mech.* **4,** 3, 321-329, July 1958.

Following earlier work by Görtler on a new series for the calculation of steady boundary-layer flows [*J. Math. Mech.* **6,** 1, 1957], author describes "a formally exact solution for the thermal boundary layer on a nonisothermal surface subjected to nonuniform free-stream velocity." The solution is presented in the form of a series. "It is demonstrated that the solution can be recast in terms of universal functions, which are independent of the wall temperature data of particular problems, and which depend only on a single parameter characterizing the variation of the free-stream velocity."

The quotations are from the author's summary.

J. T. Stuart, England

1497. Stein, R. P., and Begell, W., Heat transfer to water in turbulent flow in internally heated annuli, *AIChE J.* **4,** 2, 127-131, June 1958.

The heat transfer from the inner of two coaxial cylinders to water flowing in the annular space has been measured for a wide range of heat flux. All measurements were made sufficiently far from the entry (at least 150 diameters) to insure steady flow, and heat-transfer coefficients were determined both for uniform heating and for a cosine distribution of heating along the inner cylinder. This last distribution is frequently encountered in nuclear reactors. The results were analyzed in various ways to provide a relation between the Stanton, Prandtl and Reynolds numbers. The best correlation between all the measurements was obtained with

$$St(Pr)_f^{2/3}(Re)_f^{0.2}(D_1/D_2)^{1/2} = 0.0200 \pm 10\%$$

where the numbers are evaluated for the film temperature, and D_1, D_2 are the diameters of the inner and outer tubes.

A. A. Townsend, England

1498. Baxter, D. C., and Reynolds, W. C., Fundamental solutions for heat transfer from nonisothermal flat plates, *J. Aero. Sci.* **25,** 6, 403-404 (Readers' Forum), June 1958.

Note briefly summarizes results of authors' analyses contained in Tech. Rept. 110, Div. of Engng. Mech., Stanford Univ., Oct. 1957, and Final Rept. Pt. III, Contract NAw-6494, Dept. of Mech. Engng., Stanford Univ., July 1957. Solutions are presented for heat flux with specified wall temperature and *vice versa*, for laminar and turbulent flow. Specified distributions include constant value, step function, linear rise (ramp), and arbitrary function. G. H. Markstein, USA

1499. Tideman, M., On the temperature distribution in thin flat plates with laminar supersonic boundary layers, *SAAB Aircr. Co., Linkoping, TN* 39, 9 pp. + 1 fig., Jan. 1958.

Author solves by an approximate analytical method the problem of heat conduction in a thin flat plate whose surface is subjected to the convective heating from a laminar boundary layer. The method used is to transform the heat conduction equation into a coordinate system where the boundary conditions can be easily handled. In this process a term is neglected which is shown by comparison with exact numerical solutions obtained by Schuh (SAAB Report LAT-O-R.4) to have negligible influence on the results.

In the treatment of the same problem by Parker in *NACA TN* 3058, the solution was obtained by series expansions, and results are extended to large values of time and of distance back from the leading edge only with difficulty. Author's approximate analytical method, however, produces results valid for all times and for all distances back from the leading edge where the assumed form of heat input is applicable.

Reviewer believes that heat conduction problems of this type would be more likely to conform to real flight situations if the thin plate were treated as a slab and heat were allowed to flow through the edge normal to the stream, as well as through the surfaces parallel to the stream. H. A. Stine, USA

1500. Lowe, G., An approximate solution of the laminar heat transfer along a heated flat plate with an arbitrary distribution of surface temperature, *J. Aero. Sci.* **24,** 12, 920-921 (Readers' Forum), Dec. 1957.

Note describes briefly several methods of calculating laminar heat transfer under conditions of variable surface temperature, and presents a simple approximate method applicable to low-speed flow over a flat plate with arbitrary distribution of surface temperature. D. R. Chapman, USA

1501. Dubinsky, M. G., Rotating gas flows (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 75-78, 1954; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6507.

The steady motion of a swirling gas flow in a cylindrical tube is examined in the section beyond the entry in which the parameters of the gas flow have attained an equilibrium condition. Applying the conditions $c_z = \text{const}$, $c_u = \Omega r$, $(1/\rho)(\partial p/\partial r) = (c_u^2/r)$ (radial velocity component $c_r = 0$), and the condition of an adiabatic flow, it is possible to determine the pressure p_a on the tube wall and the pressure p_0 at the center of the tube from the quantity of motion Φ_0, moment of the quantity of motion Γ_0, flow volume G_0 and the kinetic energy E_u of the rotational motion of the gas, E_u flowing in one second through any initial cross section of the tube. In the foregoing, c_z and c_u are, respectively, the axial and tangential components of the flow velocity. Adding the condition that the entropy of the gas attains a maximum at the given kinetic energy of rotational motion of the gas, an iso-perimetral problem is obtained, leading to the solution $(p - p_0/\rho - \rho_0) = \text{const}$.

This condition is satisfied in the particular case by a constant thermodynamic temperature of the gas along the radius. It is demonstrated that for a given moment of quantity of motion the minimum kinetic energy of the gas E_u corresponds to a velocity

distribution along the radius according to the law for a solid body.

G. A. Tirskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1502. Tsarenko, N. V., Investigation of heat emission in the case of turbulent flow of liquid in narrow channels of rectangular section (in Russian), *Izv. Kievsk. Politekhn. In-ta* **17,** 143–153, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5687.

The results are given of an investigation of heat exchange to cover the case of the cooling of water moving along a straight channel of rectangular section, in the range of Reynolds numbers from 1×10^4 to 6×10^4 during changes of the relative height of the channel from 3 to 10, the relative length from 70 to 200 and with a minimum width of the channel of 1.8 m. A description is given of the apparatus used, and some points of experimental procedure are looked into. Formulas and graphs show the data obtained and their comparison with data of other authors. For the determination of the intensivity of the heat exchange a formula is proposed $N = 0.023\, R^{0.8} P^{0.4}$, where N is Nusselt number and P Prandtl number. As determining dimension the equivalent diameter $d = 4f/u$ is used, where f is the plane of the transverse section of the channel and u is the wetted perimeter. The physical constants are referred to the mean temperature of the liquid. The influence of the R number was not gone into. It is noted that free convection does not appear to influence the intensivity of the heat exchange. Nor is any reference made of the influence of the stabilizing portion. It is stated that there is good convergence of the data obtained with the investigational results, concerning the case of heating of the air. The ideas explaining this concordance as due to the different effects of the influence of the temperature on the properties of the gases and dripping liquids are not very convincing.

A. A. Gukhman

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1503. Romanovsky, S. A., Investigation of the heat transfer and resistance of tube bundles in the transverse flow of a liquid (in Russian), *Izv. Kievsk. Politekhn. In-ta* **17,** 134–142, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6814.

As a result of experimental investigations on the heat loss from staggered tube bundles in the transverse flow of a liquid, made on models with a relative pitch of $s/d = 1.5$, 1.75, and 2.3, over a range of Reynolds numbers between $R = 4 \cdot 10^3$ and $9 \cdot 10^4$, and at temperatures of 40–90°, the following formula was obtained

$$N_f = 0.38\, R_f^{0.6} P_f^{0.4} (P_f/P_\omega)^{0.25} \qquad [5]$$

where P = Prandtl number. It is demonstrated that the nondimensional parameter $(P_f/P_\omega)^{0.25}$ suggested by I. A. Mikheev permits generalization of the data on heat loss in the flow of a liquid and a gas, respectively.

Experiments on the investigation of the hydraulic resistance of tube bundles have been made only in isothermal conditions. The results of these experiments are represented in the form of the empirical relationship

$$E = (1.143\mathrm{m} - 1.6) \left(\frac{\delta}{\delta - 1}\right)^{0.408} R^{-0.378 + 0.0075\mathrm{m})} \qquad [7]$$

where E = Euler number, m number of rows of tubes in the bundle, δ pitch/diameter ratio.

S. O. Apel'baum

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1504. Voronin, V. I., The resistance and heat emission of a cone situated in a flow of a gas at supersonic velocity (in Russian), *Trudi Voronezhsk. In-ta* **42,** 2, 13–14, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6793.

A laminar boundary layer is examined on a cone with a variable temperature along the generating line of the cone. According to Chapman and Rubesin, author finds a similar solution, reducing the expressions to the form of the equation for the flat plate. Author has allowed an error to occur in the solution of the equations of heat transfer.

G. S. Glushko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1505. Shestopalov, V. P., General solution of the problem for thermal boundary layers in diffusers (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 3–9, Aug. 1956.

Generalization of Pohlhausen's solution for thermal boundary layer on flat plate is given for case of two flat plates inclined under angle and forming diffuser. Mathematical formulation of the problem makes use of Prandtl's equations of boundary layer supplemented by equation for thermal boundary layer. Technique of solution draws amply on existing methods contained in classical work of Pohlhausen and some previous work of the author. Resulting final solution for Nusselt number indicates square root dependence on Reynolds number and complicated dependence on Prandtl number, whereby the latter depends on diffuser angle.

Reviewer believes that boundary conditions underlying this solution render it unrealistic in the vicinity of diffuser's throat.

B. Zarwyn, USA

1506. Malkus, W. V. R., and Veronis, G., Finite amplitude cellular convection, *J. Fluid Mech.* **4,** 3, 225–260, July 1958.

Consideration is given to steady, cellular motions within a horizontal fluid layer which is heated from below and where the Rayleigh number exceeds the critical value. Treatment is highly mathematical. Present paper represents an important advance over previous analyses which have been concerned with determining the critical Rayleigh number at which the quiescent regime (no motion, pure conduction) becomes unstable.

E. M. Sparrow, USA

1507. Hide, R., An experimental study of thermal convection in a rotating liquid, *Phil. Trans. Roy. Soc. Lond.* (A) **250,** 983, 441–478, July 1958.

An investigation of the flow field of a liquid with uniform rotation between two concentric cylinders kept at different temperatures. In essence this work is a worthwhile extension of Proudman and Taylor's work for an inhomogeneous cylindrical motion with varying degrees of rotation and imposed temperature gradients. The combined effects of the density gradients and Coriolis forces on the planar motion perpendicular to the axis of rotation are studied experimentally, with some analytical verifications. With a prescribed temperature difference at the boundaries with variation of the angular velocity, a convective radial velocity is induced that forms wave-like flow patterns, whose wave number increases with increasing angular velocity. For small values of rotation, the flow has a quasi-horizontal wave-like pattern resembling a meandering jet stream. Possible applications of this analysis to the general atmospheric circulation and on geomagnetism from the earth's core are discussed.

S. Eskinazi, USA

1508. Globe, S., and Dropkin, D., Natural convection heat transfer in liquids confined by two horizontal plates and heated from below, Heat Transf. Inst. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 156–165.

Authors measured convective heat transfer between horizontal circular plates for water and silicone oils (plates 5-in. diameter

and 2 in. apart), and for mercury (plates 5.28-in. diameter and 1.39 and 2.62 in. apart). Lower plates were heated electrically. Experiments covered Rayleigh numbers from 1.51×10^5 to 6.76×10^8 and Prandtl numbers from 0.02 to 8750. Flow was turbulent. Relationship obtained, $Nu = 0.069 (Ra)^{1/3} Pr^{0.074}$ (Nu and Ra based on distance between plates), is in fair agreement with other authors (e.g. Malkus, AMR **8** (1955), Rev. 3907). Effect of changing distance between plates was negligible in mercury experiments, temperature fluctuations of $\pm 10\%$ of ΔT were found in mercury experiments for $Ra > 10^5$.

R. N. Cox, England

1509. Nikonorov, V. A., Aerodynamic investigation of furnaces of high thermal pressure (in Russian), Avtorefer. Diss. Kand. Tekhn. Nauk, Mosk. Vyssh. Tekhn. Uch-shche, Moscow, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5717.

1510. Scott, C. J., Analysis of a transpiration-cooled hemisphere-cylinder, *J. Aero. Sci.* **25**, 6, p. 397 (Readers' Forum), June 1958.

Method for predicting effect of air injection on heat transfer to isothermal blunt-nosed bodies is presented. Main assumptions are: constant Prandtl number, small temperature differences, and local applicability of the Falkner-Skan solutions. As an example, local heat-transfer parameter along isothermal surface of transpiration-cooled hemisphere-cylinder at free-stream Mach number of 3.6 is shown. Injection of air markedly decreases heat-transfer coefficient.

N. Tetervin, USA

1511. Hartnett, J. P., and Eckert, E. R. G., Mass transfer cooling with combustion in a laminar boundary layer, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 54–68.

Calculations are performed on mass transfer cooling with combustion for a simplified model considering a laminar boundary layer of the wedge type, constant physical properties equal for all components, infinite chemical reaction rate and equilibrium close to complete combustion. Concentration and temperature profiles within the boundary layer, the position of the flame sheet and the heat flow rate to the surface are calculated. Numerical results are presented for the representative reactions $2H_2 + O_2 = 2H_2O$; $C + O_2 = CO_2$; and $2C + O_2 = 2CO$.

Y. S. Touloukian, USA

1512. Gold, L., Statistical-kinetic theory of phase change, *J. Chem. Phys.* **29**, 1, 51–55, July 1958.

Reaction rate kinetics is applied to the phenomenon of phase change. Two rate constants, one for nucleation and the other for growth processes, are embodied in the theory. These microscopic parameters are of a basic nature, with a significance quite distinct from the macroscopic quantities employed by Johnson-Mehl and Avrami (JMA) in the conventional phenomenological formulation. Expressions for the nucleation rate and the degree of transformation are established once the basic properties of the Poisson exponential binomial limit distribution have been determined. The statistical kinetic theory does indeed lead to a sigmoid-shaped transformation curve commonly observed in phase changes. An essential ingredient of the present theory, not incorporated in the JMA phenomenological theory, is the role of nuclei and specimen size; unusual behavior may be expected in small particles undergoing transformation.

From author's summary

1513. Levy, S., Generalized correlation of boiling heat transfer, ASME-AIChE Joint Heat Transfer Conf., Chicago, Ill., Aug. 1958. Pap. 58-HT-8, 6 pp.

Good agreement between test results and the derived equation was obtained for pool boiling and nucleate boiling heat transfer of subcooled liquid with very low (a few per cent) quality of vapor, x.

In Eq. [11] of the paper, it is suggested that q/A at constant T should vary directly with $(1 - x)$ in a forced convection boiling system such as in a tube. This is incorrect, since practically all experimental results show q/A in this region actually increases slightly along a tube as quality increases—until the burnout point is reached.

W. M. Rohsenow, USA

1514. Chernobyl'skii, I. I., and Tananaiko, Yu. M., Investigation of heat emission to boiling water in a circular space at moderate thermal flows (in Russian), *Izv. Kievsk. Politekhn. In-ta* **17**, 61–74, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5704.

An investigation and its results (experimental) are reported on the heat emission to boiling water in ring-shaped slots at atmospheric pressure and at moderate thermal flows $q = (20\text{–}121) \times 10^3$ K cal/m^2 hour, approximating the conditions met with in industrial evaporating plants. The experiments were carried out in an apparatus (the design is given) furnished with heating of the boiling tubes by steam, superheated up to 1–2° at pressures of 1.28–2.46 atm, and with a closed circuit of circulation through secondary steam in the case of exterior heating. The seamless normally oxidized boiling tubes, used without any special treatment, had the following characteristic dimensions: for a steel heating surface $d = 27/21.5$ mm, $L = 480$ mm; for a copper one $d = 24.5/19.5$ mm, $L = 603$ mm. In the experiments the heat emission was investigated for ten ring-shaped slots of width δ from 1.25 to 14 mm, formed with the aid of inserts in the boiling tubes, strengthened by means of special adapters. Calculation formulas are given. It is established that the relative error in the determination of the coefficient of heat emission a_2 was found to be within the limits 6.8–8.4%. The visual observations and investigations of heat emission were considered separately. For the visual observations of the boiling process with internal heating and external ring-shaped slots (δ equal to 2.75, 6.75, 10.7 and 14 mm) an exchange was provided for of the ordinary outer shell by a shell made from a special heat-resisting glass. It appeared that the constriction of the slots causes a reduction in the dimensions of the steam bubbles, a violent turbulence in the flow, and an increase in steam content.

The data obtained in this heat emission study is presented in the form of graphs and tables. From their analysis the following deductions emerge: (1) For identical widths of the slot the coefficients for a_2 for the internal and external slots are identical. (2) The material forming the heating surfaces when δ is identical does not influence the value of a_2. (3) With a reduction of the dimensions of the slot to the magnitude corresponding to the stage of the disruptive diameter of the steam bubble the heat emission begins to drop at the determined "breaking" value of q, depending on the piezometric level of the boiling liquid, on the width of the slot, and, apparently, on the properties of the liquid. (4) With a diminution of the width of the slot (q remaining the same in all cases) a_2 increases with a simultaneous decrease of the wall temperature.

Further, a generalization of the results obtained is submitted. In the well-known equations in criterial form a correction is introduced for the dimension of slot δ which enables them to be used at magnitudes for δ of the order of the breaking diameter of the steam bubble. The original equations lead in this case to large errors. In the general part of the paper an account is given of the history of the problem and the physical side of the investigated processes is explained.

G. E. Khudyakov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1515. Bondar', A. G., Experimental investigation of heat emission to a boiling solution of caustic soda in a vertical tube with natural circulation (in Russian), *Izv. Kievsk. Politekhn. In-ta* **17**, 83–97, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5703.

1516. Bauer, E., and Zlotnick, M., Evaporation into a boundary layer. II. Dissociation in evaporation, AVCO Research and Development Division, RAD-TM-58-126, 14 pp., Nov. 1958.

The rate of evaporation of a wall material BO into the boundary layer produced by air flowing across its surface is examined. In particular, authors consider the case of the wall material dissociating into B and O in evaporation, in extension of earlier work that did not consider dissociation. The result is similar to that obtained previously, though it holds under more restrictive conditions: in the (physically reasonable) case of a "catalytic" wall, diffusion rather than evaporation limits the rate of mass loss in a continuum flow.

From authors' summary

1517. Davidov, A. A., An investigation of flow pulsations in the evaporator tubes of straight-flow steam boilers (in Russian), "Hydrodynamics and heat exchange during boiling in high-pressure boilers," Moscow, Akad. Nauk SSSR, 1955, 137–154; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6926.

Results are presented of an investigation into the pulsations of the water flow and steam in heated parallel-connected tubes for the case of forced circulation of the steam-water mixture. The experiments were made on two test stands with electrical and steam heating of the tubes at pressure between 10 and 90 kg/cm^2.

The experimental results are evaluated in nondimensional coordinates. Author endeavours to elucidate the influence of pressure, velocity of the liquid flow, heat loading, length of (tube) coil, and some other factors, on the amplitude and period of the pulsations and on the phase-displacement between the fluctuations of the pressure and the flow volume.

It is found that the amplitude of pulsations diminishes with increasing weight loading, increased pressure, and increase in relative length of the economizer section. If the tube coil is throttled at the outlet, with increasing dryness of the steam at the exit, and particularly in the presence of superheating, the amplitude of the pulsations increases appreciably.

Z. L. Miropol'skii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1518. Berman, L. D., and Stoliarov, B. M., Experimental data on the effect of a flow of substance on the heat and mass exchange during condensation (in Russian), *Teploenergetika* **4**, 1, 49–52, Jan. 1957.

1519. Tkachev, A., An approximate theoretical solution of the problem of convective heat exchange in fusion and freezing (in Russian), *Kolodilnaya Tekhnika* no. 2, 50–54, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6827.

The method of integral relationships is used to give a solution of the problem of the flow around a plate of an incompressible fluid during fusion or freezing of the fluid on the plate. The fluid flow is assumed to be laminar. The rate of fusion or freezing is assumed to be constant over the length of the plate. The problem is solved for both constrained and free convection. The results of the analysis are presented in the form of tables composed for different values of the Prandtl number and showing the variation of the Nusselt number in relation to the rate of fusion (freezing), and the thickness of the boundary layer. The tables show that the value of the Nusselt number varies considerably during solidification.

G. S. Glushko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1520. O'Brien, B. J., and Wallace, C. S., Ettingshausen effect and thermomagnetic cooling, *J. Appl. Phys.* **29**, 7, 1010–1012, July 1958.

If a material is carrying current at right angle to a magnetic field, there will be a thermal gradient at right angles to both the electric and magnetic fields. This is the Ettingshausen effect. Authors show that both the temperature difference and efficiency of cooling is improved by tapering the material so that the cooler portion is thinner than the hot. Optimization shows that the sides connecting cool and hot surfaces should be of exponential shape. Experiments with a 99% Bi and 1% Pb alloy carrying 5 amp in a 1000-gauss field resulted in 0.25°C cooling.

P. P. Biringer, Canada

Book—1521. Kays, W. M., and London, A. L., Compact heat exchangers, New York, McGraw-Hill Book Co., Inc., 1958, xii + 156 pp. $6. (Republication of 1955 edition).

See AMR **9** (1956), Rev. 2735.

A comprehensive treatment of compact heat-transfer surfaces, including all of the types in use today. Types of surface dealt with are: (1) tube banks, including both circular and flattened tubes, with both inside and outside flow; (2) plate-fin surfaces, with a variety of fin types; (3) finned tube surfaces, with both circular and flat tubes and various types of fins; and (4) screen and sphere matrix surfaces. In all, basic heat transfer and flow friction test data are presented for a total of 88 surface configurations.

In addition, authors consider a number of analytical solutions for abrupt contraction and expansion pressure-loss coefficients, laminar-flow heat transfer in circular and rectangular tubes, and the effects of temperature-dependent field properties on heat transfer and flow friction.

The purpose of the book is to make readily useful to heat-exchanger designers the results of experimental and analytical work on compact heat-transfer surfaces.

A chapter is devoted to heat-exchanger performance theory, developed around the effectiveness versus number of heat-transfer units (NTU) concept. Use of the data and the theory is illustrated by sample problems in an appendix. Another appendix presents some of the derivations for the effectiveness versus NTU relations, and illustrates the method of approach.

An objective of the authors is a common treatment of all the surfaces considered, thus avoiding the confusion so often encountered with a large number of arbitrarily defined parameters. The resulting simplification for the heat-exchanger designers is quite apparent.

From authors' summary

1522. Zeyns, J., Cooling problems in design of internal combustion engines (in German), *Motortech. Z.* **18**, 12, 378–383, Dec. 1957.

After discussing the merits of air-cooling versus water-cooling, examples of heat-transfer characteristics are given. Air-cooling data and nomograms are treated thoroughly. Different fin forms and materials and arrangements for internal combustion engines are discussed. The paper is of great help to the engine designer as it combines theoretical data with actual values from internal combustion engine practice.

M. Rand, Canada

1523. Romanovskii, S. A., Problem of the method of local modelling (in Russian), *Izv. Kievsk. Politekhn. In-ta* **17**, 130–133, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5695.

Results are given for the investigation of heat exchange in the flow through a multi-tube heat exchanger ($s_1 = 1.5\,d$, $s_2 = 1.3\,d$) in the range of R numbers from 4×10^3 to 60×10^3. The tests were undertaken to check the applicability of the so-called "method of local modelling" (i.e. approximate modelling, when the conditions

of similarity do not hold good for the whole system but only for its separate components, or even for only any one of its components). Results are compared for those obtained in the case of a single heated tube and for the system of heated tubes. Agreement reported was good. A. A. Gukhman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1524. Smith, G. C., and Beckmann, R. B., Individual film coefficients of mass transfer in liquid-liquid extraction, *AIChE J.* **4,** 2, 180–189, June 1958.

A study has been made of the individual film coefficients of mass transfer for two binary liquid-liquid systems of differing physical properties, namely methyl isobutyl carbinol-water and methylethyl ketone-water, in a 4-in. diam extraction column operated as a spray column and with ½-in. Raschig ring packing. The value of H_t for the dispersed phase was found to be a constant, C_1, for a given system in a given column. The H_t values for the continuous phase could be correlated by the equation

$$(H_t)_c = C_2(V_c/V_d)^n.$$

Values of the constants C_1, C_2, and n are tabulated along with the values found by earlier investigators for other systems and column packings. The H_t values have been reduced to area base coefficients by the expression for droplet surface area proposed by Gaylor and Pratt.

Presaturation of either phase was found to have no effect on mass transfer rates. There appears to be relatively little difference in the efficiency of spray and packed columns for systems of low interfacial tension, but for high interfacial-tension systems packed columns are considerably more efficient than spray columns.

While no definitive correlations for the effect of physical properties are proposed, there are some indications that n is a function of the viscosity ratio of the two liquid phases and that C_2 is a function of the ¼ power of the groups $(d\Delta\rho\gamma/\mu_c^2)(\mu_c/\mu_d)$ and $(N_{Sc})_c$. No correlation was found for the effect of physical properties on $(H_t)_d$. From authors' summary

1525. Slattery, J. C., and Bird, R. B., Calculation of the diffusion coefficient of dilute gases and of the self-diffusion coefficient of dense gases, *AIChE J.* **4,** 2, 137–142, June 1958.

A corresponding-states correlation of low-density binary- and self-diffusion coefficients is presented. The equations are simple to use, are sufficiently accurate for most calculations, and correlate those data used in their derivation somewhat better than calculations based on the Lennard-Jones potential if potential parameters have to be estimated from the critical properties. The Enskog kinetic theory of dense gases is used in modified form to obtain an expression for the high-density diffusion coefficient for isotopic mixtures in terms of the viscosity and compressibility of the gas. Generalized viscosity and compressibility charts are then used to construct a graph for predicting a reduced self-diffusion coefficient as a function of reduced temperature $T_r = T/T_c$ and reduced pressure $p_r = p/p_c$. The effect of the pressure on the Schmidt number, $Sc = \mu/\rho \mathfrak{D}$, is also discussed. Finally, the extension of this chart to nonisotopic mixtures is considered.

From authors' summary

1526. Tamoczy, T., and Tamas, G., Additional investigations on the positive influence of ultrasonics upon diffusion (in Hungarian), *Magyar Fiz. Foly.* **5,** 3, 237–243, 1957.

1527. Schwarz, L., Elevating the heat transfer coefficient of surface condensers by de-aeration of cooling water (in German), *Brennstoff-Wärme-Kraft* **10,** 5, p. 224, May 1958.

1528. Goitein, E. E., Cooling towers, *Mech. Engng., N. Y.* **80,** 5, 74–78, May 1958.

1529. Walter, L., Aspects of drying of paints by convection and reduction: technical and economical aspects (in French), *Chaleur et Industrie* **38,** 388, 288–296, Nov. 1957.

1530. Buckland, F. F., (Mrs.), How to read heat transfer in Russian, *Mech. Engng., N. Y.* **80,** 9, 60–63, Sept. 1958.

Combustion

(See also Revs. 1401, 1596)

1531. Spalding, D. B., and Smith, A. G., Combustion of liquid and solid fuels as boundary-layer problem (in German), *Brennstoff-Wärme-Kraft* **10,** 6, 271–273, June 1958.

By analogy to heat transfer, a mass transfer equation is derived under the assumption that (1) the flow is laminar, (2) the boundary layer is not detached, (3) constant material characteristics, (4) equal values of the coefficients of diffusion and of heat conductivity. The solution, *Nu* as a function of *Re, Pr, Eu* and velocity, is first applied to a wedge-shaped body; its generalization is the classical continuation problem of the boundary-layer theory.

W. Gumz, Germany

1532. Fetting, F., Choudhury, A. P. R., and Wilhelm, R. H., Influencing the stabilization of turbulent flames through the addition of auxiliary gases (in German), *Brennstoff-Wärme-Kraft* **10,** 6, 279–280, June 1958.

The effect of small quantities of tracer gases (H_2, O_2, C_2H_4) on the limits of stabilization is determined experimentally. The small boundaries of the "dead water" seem to play a big role in the process of stabilization. The shape and the length/diameter ratio of the flame holder is also important.

W. Gumz, Germany

1533. Laffitte, P., (edited by), Symposium on combustion of gaseous mixtures (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liq.* **13,** 4, 313–730, Apr. 1958.

This volume contains forty-two papers communicated to the XVIth Congress of Pure and Applied Chemistry, Paris, July 1957. They fall within a broad definition of combustion studies as including slow oxidation and explosion limits (17 papers covering work on such materials as carbon monoxide, hydrogen, hydrocarbons, mercaptans, aldehydes and solid carbon), flash photolysis and flame spectroscopy (5 papers), flame speed measurement and theory (8 papers), ionization in flames and studies of ignition, and combustion in high-velocity gas streams and rockets. The content of about a half of the total number is available elsewhere in the literature in English language papers. Of the remaining papers, the following are thought likely to be particular interest to AMR readers.

Paper no. 27 by Khitrin and Golovina reports results on the effects of preheat on speeds of burner flames in laminar and turbulent regions for gasoline/air flames, and paper no. 28, by Goldenberg and Pélévine, the effect of reduced pressures on gasoline/air and methane/air/carbon dioxide flames. Other flame speed data reported are for hydrazine vapor and hydrazine mixtures with air, oxygen, nitrous oxide and nitric oxide (15, 16 and 17) and for nitric oxide mixtures with hydrogen, carbon monoxide, methane and ammonia (20).

Of the two papers which concern flame stabilization in high velocity streams, the first, by S. Barrère and M. Barrère (37), gives detailed results on the application of CH/C_2 emission band ratios to the study of flames stabilized (a) on bluff bodies and (b) on pilot jets. These are discussed in terms of the variation with mix-

ture strength and the importance of mixing of fresh and burnt gases. Paper no. 38 by Rappeneau reports results on a similar problem obtained by gas sampling techniques with chemical analysis.

There are two papers relating to rocket combustion problems. That by Makovky (21) proposes that the L^* requirement for decomposition of nitro-paraffins is determined by the rate of decomposition of nitric oxide. In support of this contention a series of values of L^* for mixtures of nitromethane with nitroethane and with nitropropane are quoted with no information on the method of measurement. Moutet, Moutet and Barrère (42) review methods of measurement of ignition delay for both gases and liquids and give the results of studies on the effect of temperature and pressure on the delay in liquid systems using nitric acid as oxidant with a variety of fuels. G. K. Adams, England

1534. Barenblatt, G. I., and Zel'dovich, Ia. B., On the stability of flame propagation *Prikl. Mat. Mekh.* **21**, 6, 856–859, 1957 (Translation by Morris Friedman, Inc., Needham Heights 94, Mass. B-135, 6 pp.).

Authors mathematically define stability of the flame propagation region. They conclude that the region always appears to be stable for the single equation case in the one-dimensional problem. This conclusion is for both thermal and chain flame propagation.

J. H. Grover, USA

1535. Peshkin, M. A., The influence of auto-turbulence on flame propagation in an engine combustion space (in Russian), *Zh. Fiz. Khimii* **30**, 2, 474–475, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6558.

An attempt is made to determine the mean value of the pulsation velocity of the turbulent motion (due to expansion of the gas during combustion) of the generated flame moving through the combustion chamber of a piston engine. The analysis, using relationships given in a paper by Karlovitz, Denniston & Wells [*J. Chem. Phys.* **19**, p. 541, 1951], shows that auto-turbulence has no material influence on the process of propagation of the turbulent flame in a light-oil piston engine. V. E. Doroshenko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1536. Weller, A. E., and Thomas, R. E., Similarities in combustion, WADC TR 55-132 (available from Off. Tech. Services, U. S. Dept. Commerce, Washington 25, D. C.), 58 pp., June 1956.

Report discusses the use of dimensional analysis for a better understanding of combustion data. The first of three parts is a discussion of the basic methods of dimensional analysis which involve the relating of variables by their positions in equations. This is an extension of the checking of mathematical formulas by equating exponents.

The second part is a mathematical formation of the extension of these methods. Rather formal derivations are given for various theorems concerning appropriate matrix transformations and the use of parameter similarities.

The third part concerns the application of these techniques in studying some of the equations of combustion, such as those describing flame speed and reaction kinetics.

The applications of dimensional analysis to combustion problems are very tentative and no results have as yet been obtained. However, many possibilities are mentioned which might prove fruitful. An extensive bibliography is included at the end of the report. J. H. Davidson, USA

1537. McGowan, I. R., and Tipper, C. F. H., The slow combustion of cyclopentane. I. Kinetics in coated and uncoated vessels, *Proc. Roy. Soc. Lond. (A)* **246,** 1244, 52–63, July 1958.

1538. McGowan, I. R., and Tipper, C. F. H., The slow combustion of cyclopentane. II. Analytical results and mechanism, *Proc. Roy. Soc. Lond. (A)* **246,** 1244, 64–77, July 1958.

1539. Poncelet, J., and Van Tiggelen, A., A new method for the conductivity of the reaction zone in premixed laminar flames (in English), *Bull. Soc. Chim. Belges* **67**, 49–63, Jan./Feb. 1958.

Experiments are related which show how thermoemission interferes in the classical probe method for the measurement of ionization in flames.

A new conductimetric method is described: (a) it measures the conductivity of the reaction zone only; (b) it does not perturb the flame front, since no probes are used; (c) it is even applicable to very hot flames.

The meaning of the measurements is discussed, and results on $C_2H_2/O_2/N_2$ flames are given.

From authors' summary

1540. Adrianov, V. N., and Shorin, S. Kh., Heat transfer in radiating combustion products flowing in a channel (in Russian), *Teploenergetika* **4**, 3, 50–55, Mar. 1957.

1541. Fraser, A. R., Radiation fronts, *Proc. Roy. Soc. Lond. (A)* **245,** 1243, 536–545, July 1958.

When intense thermal radiation penetrates into a cold fluid the front separating hot and cold fluid may be well defined. When this is so, conservation laws, similar to those which are used across a shock front, can be applied to the radiation front. These conservation laws, together with the second law of thermodynamics, are used to classify the types of front which can exist. Analogies are drawn between radiation fronts and detonation waves or deflagration waves.

From author's summary by K. Stewartson, England

1542. Timofeev, V. N., and Uspenskii, V. A., Convective heat exchange in gas fuel combustion (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 111–114, Sept. 1956.

1543. Traustel, S., On the length of the diffusion flame with gaseous as well as atomized liquid and solid fuels (in German), *Brennstoff-Wärme-Kraft* **10**, 8, 367–369, Aug. 1958.

Based on the theory of a free jet (after H. Schlichting), the progress of mixing of the jet and its environment can be calculated. In this way the calculation of the size and shape of a diffusion flame is deduced. The length of a turbulent flame is equal to $l = A \cdot d (2/3 + B)$; A = constant, d burner diameter, B required air volume.

W. Gumz, Germany

1544. Fine, B., Effect of pressure on turbulent burning velocity, *Combustion and Flame* **2**, 2, 109–116, June 1958.

Turbulent burning velocities (S_T) were measured for three systems [a, propane-air; b, hydrogen-air; c, propane—(50% oxygen—50% nitrogen)] over a range of pressure at nearly constant Reynolds number. Author simply divides mean turbulent flame surface area measured from negatives into corrected volumetric flow rate to obtain S_T. For (a) a pressure exponent of 0.00 is found; for (b), 0.5; and for (c), 0.4. Author admits inadequacy of method prevents correlation of results. I. Glassman, USA

1545. Surugue, I., The stabilized core of a flame held through a drag body (in German), *Brennstoff-Wärme-Kraft* **10**, 6, 274–278, June 1958.

Flame stabilization could be explained as a compromise of the theories by J. P. Longwell and A. Mestre, as demonstrated by a variety of experimental methods (observation of a sodium-covered wire, the shadow method, the interference schlieren method, micro-gas analysis, and spectrographic determination of radials). The core behind the flame holder is ellipsoid-shaped, its length is a

function of the velocity. With increasing fuel ratio, the zone of intensive combustion is enlarged and the core is subsequently reduced in its size until it is blown off. Stabilization thus appears as an exchange of heat and of active centers through the core.

W. Gumz, Germany

1546. Vlasov, K. P., On the method of determination of turbulent flame velocity (in Russian), *Zh. Tekh. Fiz.* **27**, 2, 338-344, Feb. 1957.

Author discusses various methods of detecting flame boundaries of turbulent flames, in connection with determination of burning velocities. Advantages of ionization probe are indicated, e.g. freedom from inertia and possibility of use inside combustion chambers. Simultaneous use of electronic probe and high-speed photography shows that ionization peak occurs at moment of flame contact with electrodes. Use of electronic probes in turbulent flame speed measurements now appears to be well substantiated [cf. Karlovitz et al. AMR **10** (1957), Rev. 2314].

J. K. Kilham, England

1547. Kopytov, V. F., New methods for gas firing (in Russian) *Vestnik Mash.* **37**, 3, 53-57, Mar. 1957.

1548. Green, L., Jr., Some properties of a simplified model of solid propellant burning, *Jet Propulsion* **28**, 6, 386-392, June 1958.

Author investigates resonant burning of a solid propellant with cross flow by treating a model which assumes coupling of two processes: (1) a heat flux from burned gases to a reaction zone across a film whose thickness is governed by aerodynamic rather than chemical factors; and (2) exponential dependence of reaction rate on temperature of reaction zone, which is determined by a heat balance. Author solves steady-state equations after making simplifying assumptions and shows that the variables are reasonably related to one another. He then uses this model for a study of nonsteady burning by a perturbation treatment of the steady-state equations. He assumes the variation of burning rate to follow the variation of reaction zone temperature with a time lag t. When the frequency of parallel velocity fluctuations resulting from acoustical oscillations is properly related to the thermal and ballistic properties of the propellant, the model predicts a resonant condition which would give rise to large fluctuations of reaction temperature. If reaction rate increases faster than linearly with temperature, as is presumed to be the case, this fluctuating temperature would cause an increase in mean effective burning rate.

Reviewer believes this treatment to be a very significant contribution to the literature of resonant solid-propellant burning, but feels that substantial further evidence is needed to establish the proposed model as entirely correct. Author has identified the reaction zone with the surface, while reviewer feels that, for composite propellants, a more likely choice for the critical part of the reaction zone would be the gaseous region just above the interface. Further understanding of the time lag t is also needed.

R. Friedman, USA

1549. Green, L., Jr., Some effects of charge configuration in solid propellant combustion, *Jet Propulsion* **28**, 7, 483-485 (Tech. Notes), July 1958.

1550. Tittor, W., (editor), The oil-heating yearbook 1958: a survey of the present status of oil heating technology, Stuttgart, Verlag Gustav Kopf and Co., KG., 228 pp. + 139 figs. + 12 tables, 1958.

This first-published yearbook treats the theory and practice of oil burning and heating considering the interest and needs of producers and suppliers of fuel oil, and of manufacturers and users of oil-burning equipment. Its principal chapters are: I. Fuel oil, as a factor of development of mineral oil economics and as a source of energy (13 pp.). Increasing consumption and markets, competitive influences. II. Characteristics of fuel sprays, their significance and measurement. (63 pp. + 48 figs. + 46 refs.) Drops, stability of spray, dynamic behavior of flame. Surface tension and viscosity. Drop-size distribution, specific surface. Dispersion and ignition, influence of temperature and pressure, ignition velocity, flame temperature, influence of distillation curve. Stability of spray, influence of air velocity, combustion control. Mixture formation, time-history of fuel combustion, influence of spray structure on combustion. Dynamics of flame pressure fluctuation, influence of burner and combustion chamber design. Researches on atomization, characteristic numbers (flow number, Rosin-Rammler distribution law). III. Types of burners and preparation of fuel for combustion (35 pp. + 40 figs. + 15 ref.) Atomizing burners (pressure atomization, air atomization, rotary burners). Evaporative burners with open and with closed systems. IV Marketing problems. V. Installation and operation of household oil-heat systems (38 pp. + 20 figs. + 25 ref.) Tanks and accessories Determination of flow quantity and nozzle size, conversion from a coal-burning system, electrical control equipment, operating requirements. VI. Patent problems and representative patents, with 15 illustrated examples (18 pp.) VII. Legal requirements, definitions, codes, standards (27 pp.) VIII. Bibliography of 40 books and 112 literature items. IX. Advertisements of about 120 firms concerned with the manufacture, installation and servicing of oil burning plants.

Each chapter is written by authoritative experts, and reflects the up-to-date status of the subject treated. The references comprise mostly German literature items, but some other sources, mainly British and American, are included.

K. J. DeJuhasz, Germany

1551. Kudrin, V. D., A swirl-cyclone combustion chamber for untreated cut peat (in Russian), *Tekstiln. Prom-st.* no. 8, 45-46, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6532.

The construction is described of a swirl-cyclone type of combustion chamber for burning untreated cut peat with a moisture content up to 58-60%. Such a combustion chamber has been installed in a two-furnace Lancashire boiler with a heating surface of $94.5m^2$, and is now in service.

I. S. Simonov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1552. Blinov, V. I., On three stages in the combustion of liquids in vessels (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 115-121, Apr. 1956.

1553. Chu, B.-T., Wave propagation in a reacting mixture, Heat Transf. and Fluid Mech. Inst., Univ. of Calif., Berkeley, Calif., June 1958, 80-90.

It is developed theoretically that the speed of propagation of a wave front ("sound speed") in a reacting chemical mixture is independent of the reaction rate. At very fast reaction rates, however, this wave front is weak and the bulk of the signal propagates at the equilibrium sound speed. Thus, experiments may not reveal the weak wave front, but instead a wave front velocity apparently depending on reaction rate and influenced by instrument sensitivity.

W. W. Soroka, USA

1554. Capetti, A., Continuous combustion problems in aero engines (in Italian), *Aerotecnica* **38**, 1, 3-7, Feb. 1958.

In this paper a survey is made of some research concerning combustion efficiency, flame stability and relighting in the combustion chambers of turbojet, turboprop and ramjet, and in afterburners. The influence of altitude and flight speed, combustor shape and size, fuel injection methods, engine compression ratio and air-fuel ratio is discussed. The difficulties of a systematic approach to

the study of such problems are pointed out as well as the many doubts arising in the interpretation of the observed phenomena.

The decrease in combustion efficiency with increasing flight altitude is discussed in some length. It is shown that some intermediate fundamental steps (flame velocity, quenching distance, vaporization time, reaction rate, fuel atomization, etc.) can explain in part the mechanism of the observed phenomena and suggest some remedies.

Some experimental results on relighting in flight are also given.

From author's summary

1555. Lavrov, F. A., and Sprintsina, E. N., Combustion with knock in compression-ignition engines (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 86–93, July 1956.

Prime Movers and Propulsion Devices

(See Revs. 1522, 1548, 1549, 1554, 1555)

Magneto-fluid-dynamics

(See also Rev. 1391)

Book—1556. Landshoff, R. K. M. (editor), The plasma in a magnetic field—a symposium on magneto-fluid-dynamics, Stanford Calif., Stanford University Press, 1958, vii + 130 pp. $4.50.

Volume of 130 pages records ten papers which were presented at a Lockheed-sponsored symposium in December of 1957. Section 1 presents two theoretical papers which treat the plasma from a kinetic point of view. Chandrasekhar gives a careful treatment of adiabatic invariants in the motions of charged particles, a subject of great importance in the design of magnetic mirrors and mirror-type machines. Rosenbluth presents a hydromagnetic basis for the treatment of plasmas and shows these equations to be valid even when effective particle collisions are so infrequent as to be completely negligible.

Section 2 has four papers on the confinement and instabilities of a plasma interacting with a magnetic field. Colgate discusses the mechanism of ion acceleration by dynamic pinch instabilities which led to the observation of large bursts of "false" neutrons. Karr presents experimental studies of the pinch effect done at Los Alamos Scientific Laboratory. Data are given for the stability studies of the straight pinch and the current distribution within the pinch discharge Weibel gives an interesting analysis of the possibility of the confinement of a plasma column by radiation pressure. Part of this treatment includes the study of charge separation. Parker considers some plasma instabilities in an interplanetary magnetic field.

Section 3 presents four papers dealing with the fluid mechanics aspects of transferring energy from the magnetic field into the plasma. Blackman and Niblett give interesting experimental results using an electrodeless discharge hydromagnetic shock tube. Shocks up to Mach 30 are produced and ionization times measured for argon and air. Kash et al. give some data on velocity measurements obtained in a T-type and a conical electrode-type shock tube. Scott et al. present interesting results of channeling a strong shock by means of an external magnetic field. In the given configuration, the magnetic interaction did not contribute any noticeable heating of the shock-produced plasma. Liepmann gives the main features and results for the Couette flow problem of a real gas in the presence of a magnetic field and briefly discusses hydromagnetics of Stokes flow.

This small volume is a worthy addition to the fast-growing literature of magneto-fluid-dynamics. R. A. Gross, USA

1557. Stepanov, V. G., Zakharenko, V. F., and Bezel', V. S., On a rotating plasma (in Russian), *Zh. Eksp. Teor. Fiz.* **34**, 2, 512–513, 1958 (Translation by Morris D. Friedman, Inc., 67 Reservoir St., Needham Heights 94, Mass., S-130, 2 pp.).

Description of experiments with a plasma and a rotating magnetic field (3000 rpm). A mercury arc provides the plasma and a small vane indicates the rotation of the fluid. Authors note that large centrifugal accelerations are possible and that mechanical strength is not the limit. R. Betchov, USA

1558. Siegel, R., Effect of a magnetic field on forced convection heat transfer in a parallel plate channel, *J. Appl. Mech.* **25**, 3, 415–416 (Notes), Sept. 1958.

The steady flow of a conducting liquid, between two parallel plates, under the influence of a transverse magnetic field has been studied by Hartmann and Lazarus [see T. G. Cowling, "Magneto-fluid-dynamics," Interscience, 1957, p. 13]. Their solution is used in the present paper to determine the temperature distribution in the liquid, which depends partly on the heat transfer across the plates and partly on Joule heating. Relatively simple expressions are found for the constant temperature gradient along the direction of flow and for the wall temperature in terms of the mean temperature of the fluid. K. Stewartson, England

1559. Chu, B.-T., Thermodynamics of electrically conducting fluids and its application to magneto-hydromechanics, WADC TN 57-350 (Brown Univ.. Div. of Engineering; ASTIA AD 142039), 31 pp., Dec. 1957.

Professor Chu has studied the thermodynamics of electrically conducting fluids from a consideration of the Helmholtz free energy per unit mass. The principle assumptions are that the fluid is isotropic and hence the free energy is independent of the orientation of the coordinate system, and that the dielectric constant and magnetic permeability are known functions of density and temperature. A consequence of these assumptions is that the free energy, and hence thermodynamic properties, all consist of the standard mechanical and thermal terms plus an electromagnetic term. The electromagnetic contribution to the entropy depends only on the derivative of the dielectric constant and the magnetic permeability with respect to the temperature. Hence if these properties are either independent of temperature (i.e. a Lorentz polarization and a perfect diamagnetic substance) or follow Langevin's assumption (a perfect dielectric and a paramagnetic substance), the familiar formula for isentropic changes holds, but the ratio of specific heat may include electromagnetic contributions.

The conservation equations are derived on the basis of the thermodynamics. Finally, Professor Chu critically discusses the energy equation of magneto-fluid-dynamics in terms of his development of the thermodynamics and the general assumptions about the dielectric constant and the magnetic permeability. This discussion shoud be recommended reading for all students of magneto-fluid-dynamics.

In the application of the results presented in this report to a situation in which the external electric and magnetic fields are strong, it should be remembered that the fields might not be isotropic since the effect of these fields is to introduce anisotropic effects. The Hall current and the propagation of acoustic waves are two well-known examples of the anisotropic processes. The effects of these anisotropies occur, for the most part, in the material properties, i.e. the viscosity electrical and thermal conductivity, etc. Consequently if these effects are allowed for, it is expected that Chu's conservation equations are still valid.

E. E. Covert, USA

1560. Cabannes, H., Flow of compressible electrically conductive fluid (in French), *C. R. Acad. Sci., Paris* **245**, 17, 1379–1382, Oct. 1957.

For compressible fluid of infinite electrical conductivity author recalls the equations of magneto-fluid-dynamics and the values of the velocity of the magneto-acoustic waves. He studies particular shock waves and extends formulas which are known in the case of a dielectric fluid. R. Nardini, Italy

1561. Kemp, N. H., On hypersonic stagnation-point flow with a magnetic field, *J. Aero. Sci.* **25**, 6, 405–407 (Readers' Forum), June 1958.

The likely value of magnetic fields in reducing heat-transfer rates at the stagnation point of a body in hypersonic flight is discussed with application to satellite re-entry problems. Main interest is centered on estimating magneto-fluid-dynamic effects in the hypersonic flow adjacent to the stagnation point.

The analysis is made for a blunt body having a spherical nose with a radially directed magnetic field and for small magnetic Reynolds numbers. The assumptions of axial symmetry and the body surface as equipotential or nonconducting allow simplification of the problem. A general solution is not obtained but an approximate series solution is obtained for flow conditions directly ahead of the stagnation point (i.e. for $\theta = 0$).

Results indicate the shock is pushed outward a small amount (detachment still of same order): the velocity gradient is decreased and the heat-transfer rates correspondingly.

A typical example based on the analysis shows small reduction in heat-transfer rates (approximately 5%). Author confirms reviewer's belief that this analysis is valid only immediately adjacent to the stagnation point subject to the assumption made.

Five pertinent references are included.

R. Culver, South Australia

1562. deLeeuw, J. H., The interaction of a plane strong shock wave with a steady magnetic field, *Univ. Toronto Inst. Aerophys. TN* 49, 47 pp. + 29 figs., + 3 tables, Mar. 1958.

Report concerns theoretical and experimental study of interaction of shock wave with a magnetic field. Although different experimental arrangements are described in report, the magnetic field is essentially either parallel to or perpendicular to axis of shock tube. The analysis considers the gas to be weakly ionized and takes into account nonconductive character of walls and nonuniformity of magnetic fields used. Calculations of report yield limiting conditions beyond which shock wave cannot be reflected off the magnetic field. Comparative calculations for neon indicate that at given pressure and shock Mach number the reflected shock wave will occur at lower magnetic field strength than would be required for the case of argon. O. K. Mawardi, USA

1563. Kulikovskii, A. G., On the flow of a conducting fluid around a magnetized body (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **117**, 2, 199–202, 1957 (Translation by Morris D. Friedman, Inc., 67 Reservoir St., Needham Heights 94, Mass., K-172, 5 pp.).

When a stream in which there is no magnetic field passes over a magnetized body, it can not penetrate the region occupied by the magnetic field if the electrical conductivity of the field is infinite. In this case, there will be a cavity outside the body and the free streamline will cover both the magnetized body and the cavity. In this paper, author first discussed the fundamental equations for such a free streamline problem. Since such a free streamline problem does not give a unique solution, author imposed some additional conditions on the magnetic field in order that the solution of the problem may be uniquely determined. Finally, author gave some simple examples of the free-stream problems such as (1) flow around a plane magnetic dipole perpendicular to the flow, (2) supersonic flow around a wedge along whose surface a current of constant density flows parallel to the edge of the wedge, and (3) supersonic flow around a cone along whose surface flows a current of constant density directed perpendicularly to the cone generators. S. I. Pai, USA

Aeroelasticity

(See also Revs. 1209, 1456)

1564. Williams, D. E., The effect of wing-tailplane aerodynamic interaction on tail flutter, *Aero. Res. Counc. Lond. Rep. Mem.* 3065, 22 pp. + 5 figs., 1958.

The mutual aerodynamic interaction of oscillating wing and tailplane is considered by use of two-dimensional incompressible-flow analysis. Wing and tailplane are assumed to lie in the same horizontal plane and an approximate solution is obtained by assuming Glauert series for the bound vorticity distributions on wing and tailplane. The coefficients in these series are given by the solution of a system of linear equations. The effects of aerodynamic interaction were found to be small with one exception, namely forces on the tail due to wing motion.

A numerical application to elevator flutter shows that the interaction has little effect on the computed flutter speed. As author points out, however, it is difficult to judge whether the effect in a real three-dimensional case will be smaller or larger, in particular if the wing wake is rolled up. M. T. Landahl, Sweden

1565. Downwash tables for the calculation of aerodynamic forces on oscillating wings, *Aero. Res. Counc. Lond. Rep. Mem.* 2956, 174 pp., 1958.

Report consists of 174 pages of tabulated values of downwash W_e due to doublet strips of strength S, $e^{-ipx/V}$ and width $2s_1$ which extend downstream from $x = 0$ to $x = \infty$. These tables are useful for calculating unsteady aerodynamic derivatives for wings of arbitrary shape using the method of W. P. Jones in R & M 2470 [AMR **6** (1953), Rev. 3847]. C. D. Pengelley, USA

1566. Luke, Y. L., Coombs, Geraldine V., and Wagner, F., Solution of the potential equation for the unsteady flow about a triangular wing with subsonic leading edges in a supersonic main stream, WADC TR 57-258 (ASTIA AD 118241), 38 pp., Dec. 1957.

Report studies solution of equation of velocity potential for a triangular wing in supersonic flow when leading edges are subsonic, as given previously by Haskind and Falkovitch [AMR **1** (1948), Rev. 353]. Report corrects numerous typographical errors and a few misstatements, and also sheds light on the pragmatic nature of the procedure for the purpose of composing numerical solutions. From authors' summary by G. Power, England

1567. Greenspon, J. E., Flutter of thin panels at subsonic and supersonic speeds, AFOSR TR 57-65 (Martin Co. ER 9934; ASTIA AD 136560), 41 pp. + 18 figs. + 4 tables, Nov. 1957.

Report presents theoretical and experimental investigations of subject problem. It concludes that: (a) Subsonic as well as supersonic flutter of skin panels is possible; and (b) such flutter is self-limited in amplitude and is not necessarily destructive.

B. Smilg, USA

1568. Kopzon, G. I., Vibration of thin-walled elastic bodies in a gas stream (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **107**, 2, 217–220, Mar. 1956.

1569. Brooks, G. W., and Baker, J. E., An experimental investigation of the effect of various parameters including tip Mach number on the flutter of some model helicopter rotor blades, *NACA TN* 4005, 23 pp. + 3 tables + 21 figs., Sept. 1958.

Experimental studies were made to evaluate some of the effects of parameters such as Mach number, blade angle, and structural damping on the flutter of model helicopter rotor blades in the hovering condition. The model blades had NACA 23012 and 23018 airfoil sections and each was tested at chordwise center-of-gravity locations of approximately 27.5 and 37 per cent chord. Data were obtained at test-medium densities ranging from 0.0012 to 0.0030

slug per cubic foot and at various pitch angles up into the stall. Mixtures of air and Freon-12 were used for the test medium in order to extend the tip Mach number range of the tests to slightly above unity.

Forward movement of the blade chordwise center-of-gravity location generally raised the flutter speeds at low pitch angles but had no appreciable effect at high pitch angles. An increase in the structural damping generally raised the flutter speed at high pitch angles. At a given pitch angle, the flutter occurred at essentially constant dynamic pressure for variations in density. A large beneficial effect of Mach number was observed near the section critical Mach number and was such that if flutter did not occur up to a tip Mach number of 0.73, it would not occur at all. Out of these studies a criterion is tentatively advanced which indicates design requirements for completely flutter-free operation of helicopter blades.

The significant flutter data for a large number of tests along with detailed descriptions of the models are included in tabular form to facilitate more detailed analyses of the results presented.

From authors' summary

1570. Gurov, A. F., Direct determination of the dynamic stiffness of airplane propellers (in Russian), *Trudi Mosk. Aviats. In-ta* no. 55, 63–92, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5932.

Aeronautics

(See Rev. 1462)

Astronautics

(See also Revs. 1138, 1634)

1571. Cap, F., The application of Gröbner's method to the solution of differential equations of the *N*-body problem of astronautics (in German), 9th Ann. Congress of the International Astronautical Federation, Amsterdam, Aug. 25–30, 1958. 5 pp.

Paper describes a series solution technique applicable to the solution of systems of ordinary differential equations. The method is based on the Lie series; the solution is represented by an absolutely and uniformly convergent infinite power series of the independent variable (say t). The technique requires the analytical evaluation of a differential operator (say D) by means of which the solution can be obtained as a map of the boundary or initial conditions.

The technique is applied to the n-body problem of celestial mechanics and a formal solution is obtained in the form $s_i = \sum_{n=0}^{\infty} t^n D^n s_i^0/n!$ where s_i represents the coordinates or the velocity components of the i-th body and s_i^0 is the corresponding initial condition.

In reviewer's opinion paper is significant regarding the practical aspects of orbit calculations as well as representing a fundamental advance in analytical dynamics.

V. G. Szebehely, USA

1572. Newton, R. R., On the optimum trajectory of a rocket, *J. Franklin Inst.* **266,** 3, 155–187, Sept. 1958.

Author investigates the variational problem of the optimum trajectory of a rocket conceived as a particle of variable mass and subject to the following forces: thrust, drag, lift and weight.

In connection with a flat earth the maximum range problem is discussed for both vacuum flight and flight in a resisting medium.

Some problems of orbital flight are analyzed, more specifically the problems of maximizing the altitude reached by a satellite in vacuum flight over a flat earth. The modifications of the above problem produced by the sphericity of the Earth and by the presence of a resisting medium are also discussed.

A. Miele, USA

1573. Roberson, R. E., Air drag effect on a satellite orbit described by difference equations in the revolution number, *Quart. Appl. Math.* **16,** 2, 131–136, July 1958.

Author improves his analysis of the effect of air drag upon a satellite orbit [Amer. Rocket Soc. Preprint 466–57] which was restricted to orbits of small eccentricity, $\epsilon < 0.01$. Expansion is taken instead in powers of a parameter which is proportional to the drag coefficient, retaining only first-order terms. An auxiliary expansion in ϵ is involved but this is now considered valid for values of ϵ as large as 0.2. A set of difference equations is derived which enables the time, radius and shape of orbit to be corrected after each revolution.

Advantage of method is that it does not require a numerical integration around each orbit, although it may require as many as 25 terms in each series for the coefficients which appear in the difference equations. The calculation must be repeated for each revolution, but accumulation of errors from revolution to revolution is avoided. The density is assumed to be an exponential function of altitude.

R. E. Street, USA

1574. Gold, L., Earth-moon rocket trajectories, *J. Franklin Inst.* **266,** 1, 1–8, July 1958.

Author analyzes simple model, consisting of stationary earth and moon, with vehicle on line of centers. Work is based on incorrect formula for point at which gravity force vanishes. Second error appears in Eq. [12], in which signs are incorrect.

It is unfortunate that these errors were allowed to appear in print, as they will no doubt be a source of confusion to many unsuspecting readers.

J. Lorell, USA

1575. Miele, A., Minimality for arbitrarily inclined rocket trajectories, *Jet Propulsion* **28,** 7, 481–483 (Tech. Notes), July 1958.

1576. Hughes, R. F., Note on ballistic trajectories and orbits, *J. Aero. Sci.* **25,** 5, 330–331, May 1958.

1577. Moore, J. R., and Greening, C. P., Fundamentals of missile guidance, *Astronautics* **3,** 5, 22–24, May 1958.

1578. Pfeffer, I., and West, G. P., How computers and simulators aid in missile development, *Astronautics* **3,** 5, 38–40, 128–132, May 1958.

1579. McFee, R. H., Missile guidance by infrared, *Astronautics* **3,** 5, 33–35, 110, May 1958.

1580. Benton, Mildred, Artificial satellites—a bibliography of recent literature: Part I—1956, *Jet Propulsion* **28,** 5, 301–302, May 1958.

1581. Eggers, A. J., Jr., and Allen, H. J., A comparative analysis of the performance of long-range hypervelocity vehicles, *NACA TN* 4046, 52 pp. + 14 figs., Oct. 1957.

Report covers in a most instructive, simplified manner the motion and aerodynamic heating of long-range vehicles of the ballistic, skip, and glide categories. The ballistic type is attractive only if the convective heat transfer is reduced by using a blunt re-entry body. The glide vehicle is superior to the ballistic one in terms of converting velocity into range, and in its ability to radiate back to the atmosphere the higher convective heat inputs. The skip-vehicle with (L/D) ratios of 1 to 4 is superior to the others in converting velocity into range but suffers from high loads and aerodynamic heating.

For very long ranges (half the circumference of the earth or more), the hypervelocity vehicles compare very favorably with the supersonic airplanes.

Some design considerations are given for the glide vehicle and a wealth of most useful data is contained in the five appendices.

H. P. Liepman, USA

Book—1582. Schieldrop, E. B., The air, New York, Philosophical Library (Series in The Conquest of Space and Time), 1958, ix + 256 pp. $12.00.

This fully illustrated story of mechanical flight forms the second of a series of four independent books on the Conquest of Space and Time.

Ed.

Ballistics, Explosions

(See Revs. 1222, 1387, 1390, 1553)

Acoustics

(See also Revs. 1328, 1454, 1526)

1583. Ribner, H. S., On the strength distribution of noise sources along a jet, *Univ. Toronto Inst. Aerophys. TN* 51, 19 pp. + 7 figs., Apr. 1958.

Spatial distribution of noise sources along a jet is found by applying Lighthill's theory to regions of similar profiles. Result of analysis is referred to noise power emitted by slices of jet normal to axis as a function of distance from nozzle. Author found that this power is independent of distance in mixing region, then falls off extremely fast (as an inverse seventh power law) in fully developed jet. These findings point to mixing region being the place where the bulk of noise is produced. Calculations of report are used to interpret Powell's experiments on effects of nozzle velocity profile on total noise power as well as behavior of corrugated mufflers.

O. K. Mawardi, USA

1584. Ribner, H. S., Note on acoustic energy flow in a moving medium, *Univ. Toronto Inst. Aerophys. TN* 21, 6 pp. + 2 figs., Apr. 1958.

Both acoustic energy density and energy flow are known to be modified by motion of the medium, as in a jet. Comparison is made of similarities and discrepancies in the formulas of three investigators in order to infer a correct formulation. Examples show how variations in the velocity of a stream carrying plane sound waves can change the linear theory acoustic energy density from positive to negative values, with corresponding changes in the energy flow.

From author's summary by O. K. Mawardi, USA

1585. Coles, W. D., Mihaloew, J. A., and Callaghan, E. E., Turbojet engine noise reduction with mixing nozzle-ejector combinations, *NACA TN* 4317, 17 pp. + 14 figs., Aug. 1958.

1586. Brun, R., Modes of vibration in an acoustic tube of non-uniform section in the region of self vibration (in French), *C. R. Acad. Sci., Paris* **246,** 17, 2450–2452, Apr. 1958.

1587. Tobias, S. A., and Fishwick, W., Theory of regenerative machine tool chatter. Pts. I and II, *Engineer, Lond.* **205,** 5324, 199–203, Feb. 1958; **205,** 5325, 238–239, Feb. 1958.

Authors present a theory in which the conditions under which chatter can exist can be surveyed at a glance and corrective measures made without recourse to tedious calculations of stability conditions. This is done by means of stability curves which aid in the most economical design, purchase and use of machine tools Authors conclude that the solution of chatter problems requires the collaboration of the machine tool designer, tool designer, metallurgist and the user.

M. S. Weinstein, USA

1588. Evans, L. M., Control of vibration and noise from centrifugal pumps, *Noise Control* **4,** 1, 28–31, 61, Jan. 1958.

1589. Numachi, F., Ultrasonic wave emitted by cavitation occuring on hydrofoil. II (in German), *Forsch. Geb. Ing.-Wes.* **24,** 3, 73–78, 1958.

Continuation of work is resumed, after long interval (20 years), on ultrasonic output due to formation of cavities in water flow past models. Factors varied include speed, cavitation number, angle of incidence (α), and temperature of water (t). Intensity of frequency components (in the ultrasonic range to 400 kc/s) of emitted noise is measured. Model in this case was a Clark Y hydrofoil. Graphs are presented of frequency spectrum for a range of static heads just upstream of model for different cavitation numbers. When α and t are variables, the mean ultrasonic output only is given. General trends in results are noted but there is no discussion of causes.

E. G. Richardson, England

Micromeritics

(See also Revs. 1226, 1550)

Book—1590. Hammond, R., Dispersion of materials, Vol. II, New York, Philosophical Library, 1958, ix + 230 pp. $10.

Book is the second volume of the series "Physical processes in the chemical industry." Intended for those studying for executive positions in the chemical industry author describes in successive chapters the wide variety of industrial apparatus used in crushing and grinding, classification, fluidization, flotation, liquid dispersions, gas dispersions and atmospheric pollution reduction. Examples of recent practical applications of equipment are freely given, with emphasis on British practice. Much of the apparatus is covered more satisfactorily in, for example, Perry's "Chemical Engineers' Handbook;" there is an impression of hasty compilation, and treatment throughout is on a rather uneven introductory level. Thus reviewer wonders how many chemically qualified students can be plunged straight into "fluidization" without wanting an explanation of the jargon (p. 69) yet not be expected to know the meaning of surface tension (p. 121) or an aldehyde (p. 195).

As a general review of the field, book may have its place on a library shelf, but the relation of price to size, quality of production and content is unlikely to appeal to the individual buyer.

K. R. May, England

1591. Deresiewicz, H., Mechanics of granular matter, Advances in Applied Mechanics, Vol. V. (Edited by Dryden, H. L., and Von Karman, Th.) Academic Press, Inc., 1958, 233–306.

This is an excellent review of the subject. Geometry of a mass of granular material is discussed from the standpoint of external shape and internal configuration of particles. Recent results of application of the elastic contact theory to obtain analytical descriptions of mechanical behavior of granular solids are presented and discussed. Behavior under both normal and tangential forces is considered. Author provides good review of mechanical response of granular assemblages from the viewpoint of continuous models and of discrete models. Cogent suggestions for further research are made, and a fairly complete reference list is cited.

S. R. Faris, USA

1592. Bachman, D., and Gerstenberg, H., Determination of grain size of plastics powders (in German), *Chemie-Ingenieur-Technik* **29**, 9, 589–594, 1957.

The grain-size distribution of several plastics powders in the subsieve range has been determined by two different sedimentation methods, namely with the sedimentation balance of the Sartorius-Werke, Goettingen, and also by the widely used pipette method of Andreasen. The mathematical foundation and the carrying out of the tests and their evaluation are discussed, and the results compared. For routine tests the sedimentation balance was found preferable as a recording instrument. Previous researches and methods, among them the photoelectric determination with the "dispersometer" of Nassenstein, are discussed. The Sartorius sedimentation balance is illustrated and described. Numerous histograms of quartz, polyvinylchloride, polyvinylalcohol and other powdered substances, determined by both methods, are shown.

This is a clear and detailed treatment of the subject, giving background and recent developments in the field of grain-size determination of particulate comminuted materials, which are of importance for chemical process engineering.

K. J. DeJuhasz, Germany

1593. Goeb, A., On grain-size determination of pigments (in German), *Fette, Seifen, Anstrichmittel* **58**, 1070–1073, 1956.

Grain-size distribution is an important characteristic of pigments, which indicates their properties for particular applications; its determination is a necessary step in pigment production. Grain micrograms and grain-size histograms are shown for chrome-orange, molybdate-orange, and red-lead oxide. The determination was made with the Sartorius sedimentation balance based on the Andreasen pipette method. The influence of grain-size distribution on the covering capacity of paints, on the properties of printer's ink, colors for printing, lacquers, rubber, plastic films, etc., and the influence of monodisperse characteristics, and the importance of preventing the agglomeration of particles are discussed. The importance of the sedimentation balance for the testing and further improvement of pigments and other comminuted chemical products is emphasized. Author gives a clear background for the evaluation of pigments and their significant properties.

K. J. DeJuhasz, Germany

1594. Shinohara, K., Tsubaki, T., Yoshitaka, M., and Agemori, C., Sand transport along a model sandy beach by wave action, *Rep. Res. Inst. Appl. Mech. Kyushu Univ.* **6**, 21, 1–24, 1958.

The phenomena occurring on a sandy beach were studied in a transparent tank with a wave-making machine, and analyzed in terms of the appropriate dimensionless ratios. The maximum depth of the water (35 cm) and the slope of the beach (0.1) were kept constant throughout. Beach profile, sand transport and suspended load were particularly analyzed.

A novel feature was the use of ground coal as well as sand, thus increasing some five times the upper range of the dimensionless ratio H_0/sD of *wave height/ submerged specific gravity of the particles × their diameter*, with the same particle size range (D was fairly uniform at 0.2 mm for the sand and 0.3 mm for the coal). This ratio was found to affect beach profile considerably—for instance, no bar was formed with the coal. Particle transport was found to be more complicated, since more ratios are involved.

C. F. Bonilla, Puerto Rico

1595. Wieland, W., Water vapor condensation on natural aerosol in case of slight saturation (in German), ETH Prom. no. 2577, 36 pp., 1956.

From a small number (approximately 10) of measurements at Locarno-Monti the following conclusions are drawn: (1) In the air near the ground sufficient condensation nuclei are found to enable condensation in the relative humidity range of 100 to 101%. (2) The nuclei which are of most importance for cloud promotion are distinguished by their size. (3) Activity and size of nuclei show a parallel trend. (4) When the aerosol consists entirely of mixed nuclei, preliminary coagulation is of great importance. (5) Nuclei of maritime origin can contribute to condensation but are not necessary, because sufficient active mixed nuclei are present.

From author's summary by D. A. De Vries, Netherlands

1596. Kling, R., Microphotographic investigation of fuel sprays in combustion chambers (in German), *Brennstoff-Warme-Kraft* **10**, 6, 257–263, June 1958.

Short-time microphotography has been used to investigate fuel sprays and flow conditions inside the combustion chamber of a jet propulsion unit. Statistical composition of fuel fog, and trajectories of individual droplets were determined. Relationship was found between the Sauter Mean Diameter (expressing the fineness of atomization) and the degree of combustion. Type of atomization has little influence on combustion efficiency. Author concludes that performance of combustion chambers at low loads and high altitude depends on the exchange of heat and mass between the fuel particles and the air, and on the reaction velocity. Improvement can be expected by better design of combustion chamber and by development of fuel additives and new fuels. The "Nene" combustion chamber, as adapted for the microphotographic experiments, is illustrated, and experimental technique is described.

Some items treated: characteristic parameters of fuel spray; influence of ambient air pressure on the spray of a swirl nozzle; typical photos of fuel sprays and their evaluation in characteristic curves; structure of fuel fog; movement of fuel drops. Discussers call attention to previous researches on sprays in diesel engines relative to influence of drop sizes on combustion efficiency.

This is a very thorough-going research, conducted with the ample resources of the French Office National d'Etudes et de Recherches Aéronautiques, which adds considerably to the existing body of knowledge in the field of liquid fuel combustion.

K. J. DeJuhasz, Germany

Porous Media

(See also Rev. 1286)

1597. Jackson, K. A., and Chalmers, B., Freezing of liquids in porous media with special reference to frost heave in soils, *J. Appl. Phys.* **29**, 8, 1178–1181, Aug. 1958.

If the surface area of a liquid is large compared to its volume, the normal freezing temperature of the liquid will be altered. In a porous material a liquid can therefore exist in equilibrium, below its normal freezing temperature. However, such a liquid will be unstable with respect to bulk solid. This instability provides the driving force for frost heave in soils.

From authors' summary

1598. Somerton, W. H., Some thermal characteristics of porous rocks, *J. Petrol. Technol.* **10**, 5, 61–64, May 1958.

Results of experimental measurements of heat capacities and thermal conductivities of some typical porous rocks are presented. Measured heat capacities agree closely with values calculated from known chemical compositions of the rocks. On the basis of this agreement, heat capacities of fluid-saturated rocks were calculated. Thermal conductivities of the rock samples were measured under various conditions of fluid saturation. From these data thermal diffusivities were calculated. A significant variation of thermal diffusivity with temperature is indicated.

From author's summary

1599. Widmyer, R. H., and Wood, G. M., Evaluation of porosity derivation from neutron logs, *J. Petrol. Technol.* **10,** 5, 57–60, May 1958.

In order to evaluate the quantitative determination of porosity by various neutron logging systems, four test wells were constructed to simulate some of the possible variables found in field logging conditions.

All of the test holes contain sections of limestone with one section of sandstone included in one well. Each well has a representative section of high, medium, and low porosity. Three borehole sizes are represented by three of the test wells, all containing fresh water. One test well contains saturated brine.

Statistical and time constant checks are made for each system evaluated. Runs and repeat runs are made with the sonde centered and eccentric.

Factors evaluated are the effect of borehole size, sonde position, salinity, chemical composition of rock, and statistical variation. A semi-quantitative method of evaluating these effects is used, giving the average maximum percentage of error possible for each. Drift and calibration procedures are also discussed.

The effect of the various factors appears to be largely a function of the phenomena detected as well as the means of detection. Graphic illustrations of some of these effects are presented.

It is concluded that for accurate log interpretation the hole size and sonde position should be known.

From authors' summary

1600. Nougaro, J., Gruat, J., and Comier, J.-J., Principles of electric analogy for the study of coefficients of discharge in the infiltration of a dam (in French), *C. R. Acad. Sci., Paris* **246,** 11, 1661–1664, Mar. 1958.

1601. Ruban, G. F., Consideration of the horizontal anisotropy of the ground in determining the flow of a filtration current under hydraulic engineering structures (in Russian), *Gidrotekh. i Melior.* no. 8, 33–40, 1956; *Ref. Zh. Mekh.* no. 6, 1957.

The well-known proposition is investigated that in estimating the amount of filtration under a hydraulic engineering structure it is necessary to take account of the change in the value of the coefficient of filtration over the depth of the foundation. The most important factor in the variation of the coefficient of filtration in the foundations of hydraulic engineering structures is wrongly considered by the present author to be the stresses in the foundation soil. This proposition is demonstrated by the author's experimental results, according to which the coefficient of filtration of a sandy soil very considerably decreases with increasing pressure on the soil. These results of the present author differ very considerably from available experimental data, and are obviously to be explained by an incorrect arrangement of his experiments.

Title of paper does not correspond with its contents, since anisotropy of the soil is not considered. Paper contains a number of erroneous conclusions. V. I. Aravin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1602. Black, W. P. M., Croney, D., and Jacobs, J. C., Field studies of the movement of soil moisture, Dept. Sci. Indust. Res., Road Res. Lab., Harmondsworth, West Drayton, Middlesex, England, Tech. Pap. 41, 74 pp., 1958.

1603. Minskii, E. M., and Markov, P. P., Experimental investigation of incomplete wells (in Russian), *Trudi Vses. Neftegaz. N.-i. In-ta* no. 8, 35–65, 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4481.

1604. Buzinov, S. N., The reestablishment of pressure in incomplete wells with a sandy layer (in Russian), *Trudi Mosk. Neft. In-ta* no. 16, 96–112, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5805.

A deduction is given for an approximate formula for the calculation of the reestablishment of face pressure after the stoppage of a hydrodynamically incomplete well in the presence of a sand plugging layer or the clogging of the face by the sand. The liquid in the sand stopper is assumed to be incompressible, while the pressure in the lower foundation of the plug is taken to be equal to the pressure (P_1) in the perforating openings. The yield of liquid (q) issuing from the layer into the well after the stoppage is determined by the formula

$$q = \frac{2\pi kb}{\mu} \frac{\overline{P}_1 - P_1}{C}$$

where $\overline{P}_1$ is the changing with time of the mean pressure along the lateral surface $2\pi r_c b$ in front of the perforated openings; C is the supplementary undimensioned filtration resistance arising from the incomplete state of the well. On the basis of these assumptions pressures $P_c(t)$ in the upper part of the plug join up with the values for pressures $P_1(t)$ and $\overline{P}_1(t)$ and then the boundary condition for $P(r, t)$ on the wall of the well is found. The original distribution of the central pressure $\overline{P}(r; 0)$ in the layer is taken from the solution for a stationary flow. Thus the solution of the problem merges with the integration of the differential equation for $\overline{P}(r; t)$, which, as demonstrated by I. A. Charnyi, has the form of $\chi \overline{\nabla}^2 \overline{P} = \frac{\partial \overline{P}}{\partial t}$, where χ is the coefficient of piezo-conductivity. The solution obtained is compared with known cessation of the flow. Conditions are established in which Masket's solution agreed for all practical purposes with the more precise and general solution of the author. The nomograms provided make the work of utilizing the calculation formulas significantly easier. A. L. Khein

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1605. Mikhailov, G. K., Rigorous solution of the problem of ground water flow from a horizontal stratum into a basin with a heavier liquid (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **110,** 6, 945–948, Oct. 1956.

In the first part of the paper the problem is explained and an approximate formula for the discharge is given based on constancy of the velocity of flow in each vertical cross section.

In the two other sections of the paper a method for rigorous solution of the same problem is outlined, and a special case is further considered. A. P. Hrennikoff, Canada

1606. Shestakov, V. M., Unsteady seepage through slanting impervious rocks (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **108,** 5, 791–794, June 1956.

1607. Numerov, S. N., Seepage in a semi-infinite earth mass (in Russian), *Izv. Akad. Nauk. SSSR, Otd. Tekh. Nauk* no. 4, 58–74, Apr. 1956.

Paper is an extension of the previous works of the author on a two-dimensional seepage flow. It deals with the shape of the top flow line at the exit from a semi-infinite homogeneous soil bank, resting in one case on a pervious foundation of the same material, and in the other case on an impervious base with a horizontal top surface. Except near the exit the top flow line conforms closely to what is called the asymptotic line, whose equation can be found. Approximate relations are used for determination of the deviation of the asymptotic line from the top flow line in the neighborhood of the exit point.

The same method is also applied to the problem of seepage through a homogeneous earth dam resting on an impervious foundation. Numerical examples are given.

A. P. Hrennikoff, Canada

1608. Bulygin, V. Ya., and Pleshchinskii, B. I., The modelling of the displacement of petroleum by side (lateral) water (in Russian), *Uch. Zap. Kazansk. In-ta* **116**, 5, 41-44, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5812.

A brief description is given of experiments on the modelling of the motion of the boundary line of two liquids in a slotted trough. In the experiments the conditions of modelling were performed in such a way that they reproduced the natural conditions. The role of a porous medium was taken by glass friable particles. The inner region, bounded by a sieve partition, was impregnated with a mixture of kerosene and α – monobromo naphtalene, the outer space was filled with colored water. The experiment was photographed. Photographs are given of the work of one or two slots.

A. R. Shkirich

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1609. Tempel', F. G., Modelling of the process of accumulation of gas in a main gas conduit (in Russian), *Gaz. Promst'* no. 7, 32-36, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5413.

It is shown that when modelling the irregular process of gas accumulation in a main operating gas line, determinable by criteria of similarity, criteria obtained by Strukhal and criteria of the form $\xi M^2 x/D$ appear; in the latter ξ is the coefficient of hydraulic resistance, D the diameter of the gas main, x its length. Here it is assumed that along the gas main the coefficient of hydraulic resistance preserves its constant value, which depends only on the relative roughness of the inner surface of the gas main. An example is investigated of the application of the conditions described for the modelling.

V. N. Gusev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1610. Gaevskii, B. A., Experimental determination of the filtration constant of fibrous suspensions (in Russian), *Izv. Kievsk. Politekhn. In-ta* **17**, 154-161, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5822.

An investigation was carried out on a laboratory filter to show the influence of the degree of reduction in size of sulphite and sulphate cellulose on the value of the specific resistance of deposits of these celluloses on a sieve filter. The value of the specific resistance of the deposit was calculated from the experimental data by means of the equation of filtration

$$\tau = b(V^2 + 2V_0V) \quad \left(b = \frac{\mu C r}{2pF^2}\right)$$

Here V is the liquid volume of the filtrate (l), V_0 is the volume of the filtrate separating out the deposit with resistance, equal to the resistance of the filter cloth on the filter sieve, τ is the time of filtration (min.), μ is the coefficient of viscosity of the medium (kg min/dm^2), C is the weight of the solid content in 1 l of liquid (kg), r is the specific resistance of the deposit (dm/kg), p the filtration pressure (kg/dm^2), F is the filter area (dm^2). It was established that the value of the specific resistance of the deposit was

(a) for sulphite cellulose:

$$r = \left(\frac{l^0}{10}\right)^{2 + \frac{p}{27}} 10^{10}\ [dm/kg]$$

(b) for sulphate cellulose:

$$r = \left(\frac{l^0}{16}\right)^{3.1 + \frac{p}{20}} 10^{10}\ [dm/kg]$$

where l^0 is the coarseness of the grinding of the cellulose in Shopper-Rigler degrees.

V. A. Klyachko

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1611. Tikhov, M. N., The flow of a liquid in a cylindrical seam to a perforated central wall (in Russian), Trudi 3-go Vses. Matem. Siezda. Vol. 1. Moscow, Akad. Nauk SSSR, 212-213; 1956; *Ref. Zh. Mekh.* no. 4, 1957, Rev. 4485.

1612. Molokovich, Yu. M., Problem on the determination of the coefficient of permeability of a layer (in Russian), *Uch. Zap. Kazanskogo In-ta* **116**, 1, 55-58, 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5795.

A hydrodynamic method is developed for the determination of the permeability of layer $K(x, y)$; in doing so it is assumed that the character of the layer is subject to water pressure, the liquid is incompressible, the filtration is laminar. The equation is made use of

$$\frac{\partial p}{\partial x}\frac{\partial \ln k}{\partial x} + \frac{\partial p}{\partial y}\frac{\partial \ln k}{\partial y} + \Lambda p = 0$$

where p is the pressure, $\Lambda = \partial^2/\partial x^2 + \partial^2/\partial y^2$. To find the sought function $k(x, y)$ use is made of the field of pressure p_1 and p_2 for two different moments of time; in this way two equations are obtained:

$$\frac{\partial p_1}{\partial x}\frac{\partial \ln k}{\partial x} + \frac{\partial p_1}{\partial y}\frac{\partial \ln k}{\partial y} + \Lambda p_1 = 0$$

$$\frac{\partial p_2}{\partial}\frac{\partial \ln k}{\partial x} + \frac{\partial p_2}{\partial y}\frac{\partial \ln k}{\partial y} + \Lambda p_2 = 0$$

Function $\ln k = \Phi(x, y, C)$ appears to be the general solution. Here C is a constant determined by the known value of k in one of the points in the layer. In analogous fashion the permeability of the layer is determined in the case of a water pressure condition with movement of the compressible liquid.

V. A. Karpychev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1613. Guseinov, G. P., Some problems arising from the change in contour of the petroleum-carrying layers and the flooding of the wells (in Azerb.), *Uch. Zap. Azerb. In-ta* no. 12, 19-29, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5800.

Some questions of change of level of the oil-bearing layer and the flooding of the wells are studied, when the conditions include a settled process of movement of an incompressible liquid in accordance with the linear principle of filtration in a horizontal homogeneous layer. The arrangement of the problem and the deduction of the equation for the movement of the contour of the oil-bearing layer are based on the investigations of V. N. Shchelkachev. The problems investigated by K. N. Dzhalilov and N. N. Baranovska are generalized for the case of the variable yield of the wells. The following particular cases of flooding of the wells were solved: (1) For one well with a rectilinear original contour of the oil-bearing layer; (2) for a well eccentrically situated in relation to the round contour of the oil-bearing layer; (3) for a rectilinear battery of alternating working and force wells; (4) for an infinite series of working wells.

Numerical examples and curves are given. An approximate method is indicated for the solution of the afore-mentioned problems, taking into account the difference in viscosities of water and petroleum. Finally, a method of integration is furnished for the equation of the movement of the oil-bearing-layer level with an elastic system of filtration operating, when one working well is in action in the endless layer.

G. S. Salekhov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1614. Barenblatt, G. I., Possibility of linearization in some problems of nonstationary gas flow through soil (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 11, 111-113, Nov. 1956.

Paper deals with the problem of axisymmetrical flow of gas through an infinite porous medium towards a vertical drill hole, the boundary conditions being: a constant pressure throughout the porous mass at the zero time, followed by a constant discharge through the drill hole, while the same gas pressure remains at infinity. By introducing a new pair of independent variables into the equation of gas flow, it is possible to linearize it by modifying some terms, after which the equation can be easily solved. The error introduced by this operation is negligible within the limits of the numerical values of the parameters describing the properties of the gas and the porous medium.

A similar linearization is apparently possible in other problems involving the gas flow. A. P. Hrennikoff, Canada

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 1507, 1582, 1594, 1595, 1643)

1615. Moran, D. F., and Cheney, J. A., Earthquake response of elevated tanks and vessels, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 2 (*J. Struct. Div.*), Pap. 1563, 14 pp., Mar. 1958.

Recent Western United States earthquakes, while not being as severe as can be expected to occur, have provided tests of many structures specifically designed to resist earthquake forces.

A method of analysis is discussed wherein minor damage to elevated water tank towers and refinery vessels can be satisfactorily explained. From authors' summary

1616. Sverdrup., H. U., Oceanography (in English), Encyclopedia of Physics **48**, Geophysics 2, Springer-Verlag, 1957, 608–670.

The late (1888–1957) Norwegian oceanographer contributed this chapter to Encyclopedia of Physics. It is a concise presentation of the entire subject, the general physics of oceans, excluding tides and waves which are postponed to another chapter of the Encyclopedia. Contents are: oceanographic instruments and methods (principles only, no detailed descriptions), ocean basins (area, volume, depths, topography, sediments), waters of oceans (salinity, density, thermal and other properties), sea-air boundary layer (winds, flux of vapor and heat), heat budget of oceans (radiation, evaporation, energy loss, heat transfer by currents), general distribution of salinity, temperature and density, water masses of oceans—Atlantic, Indian and Pacific, applications of hydrodynamics (motion, pressure, currents, relation between winds and currents), currents of oceans—the upper layer and deep water circulation. This chapter is an example of a condensed and bright treatise. S. Kolupaila, USA

1617. Greenspan, H. P., On the breaking of water waves of finite amplitude on a sloping beach, *J. Fluid Mech.* **4**, 3, 330–334, July 1958.

In a recent paper Carrier & Greenspan [title source **4**, no. 1, 1958] showed that, within the framework of the nonlinear shallow-water theory, there exist waves which do *not* break as they climb a sloping beach. The formation of a shock or bore is dependent on a variety of factors (wave shape, particle velocity, etc.) and, as yet, no general criteria for breaking have been found. In this paper, author considers waves which propagate shoreward into quiescent water; it is shown that any compressive wave (a wave of positive amplitude) which has a non-zero slope at the wave front eventually breaks before reaching the coastline. In fact, an explicit relation is obtained between the initial conditions and the position where breaking occurs.

From author's summary by H. G. Farmer, Jr., USA

1618. Rundgren, L., Method for calculation of maximum wave dimensions applied to the conditions at Lushington Shoals (in English), *Trans. Roy. Inst. Technol., Sweden* no. 125, 38 pp., 1958.

Investigations for a proposed lighthouse at Lushington Shoals on the west coast of India. Long-term meteorological observations at two nearby stations were applied for computation of the maximum wave dimensions to be expected. Two different kinds of wind were studied: monsoon winds of long duration and the cyclones, short and strong. In summer of 1953 stereophotogrammetric measurements were carried out in the vicinity of shoals, in order to check the calculated dimensions, primarily by the Sverdrup and Munk theory. The waves created by a cyclone were estimated considerably higher than those generated by monsoon winds. Maximum wave height of 50 ft and length of 600 ft are forecasted for the site of lighthouse. S. Kolupaila, USA

1619. Lacombe, H., Mechanical energy of waves: state in nature (in French), *Houille Blanche* **12**, 5, 731–745, Nov. 1957.

1620. Gougenheim, A., Mechanical energy of tides: state in nature (in French), *Houille Blanche* **12**, 5, 746–755, Nov. 1957.

1621. Gridel, H., Mechanical energy of waves: scale model tests (in French), *Houille Blanche* **12**, 5, 756–764, Nov. 1957.

1622. Vantroys, L., Mechanical energy of tides: scale model tests (in French), *Houille Blanche* **12**, 5, 765–777, Nov. 1957.

1623. Gariel, M., Harnessing the mechanical energy of the waves (in French), *Houille Blanche* **12**, 5, 778–783, Nov. 1957.

1624. de Rouville, A., Harnessing the mechanical energy of tides (in French), *Houille Blanche* **12**, 5, 784–806, Nov. 1957.

1625. Laval, D., Harmful effect of wave and tide (in French), *Houille Blanche* **12**, 5, 807–822, Nov. 1957.

1626. Grushevsky, M. S., The determination of the profile of a wind-induced long wave (in Russian), *Trudi Gos. Okeanogr. In-ta* no. 33/45, 99–114, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6717.

The problem is investigated of the propagation of a long plane wave of small amplitude under the action of a moving wind system. The equations of motion of a long wave in a channel of variable depth furnish, after the introduction of a series of assumptions, the following fundamental equation for the rise in level ζ:

$$\frac{\partial^2\zeta}{t^2} - gH\frac{\partial^2\zeta}{\partial x^2} - g\frac{dH}{dx}\frac{\partial\zeta}{\partial x} = -\frac{\partial}{\partial x}\left(H\frac{\partial\omega}{\partial t}\right)$$

in which $\omega(x,t)$ = vertically averaged flow velocity due to the wind force, $H(x)$ = depth of channel, g = acceleration of gravity, x = distance along the channel, and t = time. For a given form of the function $\omega(x,t)$, author analyzes in detail the solution of the equation obtained for the case of a constant depth and, in general terms, for the case of a variable depth. The results obtained indicate the presence of the phenomenon of resonance when the velocity of the wind system coincides with the free-wave velocity in the channel. Yu. M. Krylov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1627. Shuleikin, V. V., Theory of sea waves (in Russian), *Trudi Mor. Gidrofiz In-ta Akad. Nauk SSSR* **9**, 143 pp. + illus., 1956; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5585.

The collated works contain the author's results, obtained principally in the "storm" basin of the Marine Hydrophysical Institute of the Akademia Nauk SSSR. The work is considered under the following headings: Deductions of classical correlations for

the deep sea. Deductions of classical correlations for the shallow sea. Group velocity of waves. Wave energy. Transfer of wave energy. Making more precise the kinematics of sea waves. Outline and basic parameters of sea waves. The physical reasons for the tapering of the crests of sea waves. Kinematics of the limited steep waves. Destruction of waves due to the action of shallow water. Genesis of wind waves on smooth water surfaces. Some hypotheses of the growth of wave energy. Apparatus for carrying out experiments in the "storm" basin. Energy balance of waves and their growth in height. Theory of the "feeding" of waves by wind energy. Theory of the increase in length of waves due to wind action. Origin of a stable dead sea swell. The behavior of waves when the wind changes direction. Control determination of the action of the basin walls. Control determination of turbulent viscosity. The development of waves from the windward shore to the lee-ward in deep seas. Egress of a swell from the storm zone in deep seas. Development of wind waves in shallow seas. Analysis of the measurement of the extent of large wind waves in the ocean. The part played by tangential forces in the action of the wind and in the increase of wave energy. Wave refraction on continental shoal waters.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1628. Brovikov, I. S., Statistical characteristics of the components of wind waves (in Russian), *Trudi Okeanogr. In-ta* **26,** 147-163, 1954; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5587.

The statistical principles of the distribution of the components of wind waves are investigated. Waves are examined as the result of unregulated interference of a very large number of sinusoids with random periods and phases. The consequent oscillation is recorded in the form of

$$U = \rho \cos (\omega_o t - \theta)$$

where

$$\rho \cos \theta = \alpha = \sum_{i=1}^{n} a \cos (\omega_i t + \varepsilon_i)$$

$$\rho \sin \theta = \beta = \sum_{i=1}^{n} a \sin (\omega_i t + \varepsilon_i)$$

The values of ω_i and ε_i are assumed to be random. With the aid of Lyapunov's theory of limitation it is shown that the random values of α and β conform to the one-dimensional normal principle of distribution. On the hypothesis of the independence of the values α and β it appears that amplitude ρ, resulting from the complex oscillation, conforms to the two-dimensional normal principle of distribution. This last deduction is later generalized to include the case where the interfering sinusoids have different amplitudes. In view of the circumstance that the height of the waves is equal to the doubled amplitudes, the deduction holds good also for the height of the waves. Further, a hypothesis is introduced to show that the relation of the height of the wave, having a final probability, to the length of the wave, having the same probability, emerges as a constant. From this position it follows that the length of the waves is distributed in accordance with the same principle as the height. Finally, utilizing the known formulas from the theory of waves, linking the length of the waves with their period and velocity of spread, and applying the known procedure of the theory of probability, author finds the principle for the distribution of the wave periods and phase velocities. Good agreement was disclosed between the theoretically obtained integral functions for distribution and the functions built up as the result of the analytical work done on the wave graph photographic films.

Yu. M. Krylov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1629. Crease, J., The propagation of long waves into semi-infinite channel in a rotating system, *J. Fluid Mech.* **4,** 3, 306-320, July 1958.

Paper presents a theoretical investigation aimed at an explanation, in part, of the behavior of tides and storm surges when they are propagated into the North Sea from the Atlantic Ocean. The coastal formation is considered through two models. In the first model, two semi-infinite barriers are situated in the path of the incident wave. In the second model, there is considered one semi-infinite and one infinite barrier. The amplitude of the wave, in general of Kelvin and Poincaré type, transmitted into the channel is investigated. The width of the channel is less than a wave length.

Considering parameters suitable to the M_2 tide at the entrance to the North Sea, the amplification of the wave in the first model is slightly greater than 2, in fair agreement with an observed value of 2.3. The second model gives a value of about 3. The principal difference between the two solutions is the occurrence of a reflected wave from the infinite barrier which introduces cancellation and reinforcement depending on the angle of the incident wave.

H. G. Farmer, USA

1630. Lauwerier, H. A., A uniform windfield on a rotating sea in presence of a semi-infinite barrier; The influence of some uniform windfields upon a sea having the form of a semi-infinite strip (in English), *Math. Centrum Amsterdam Rap.* TW 50, 6 pp. + 2 figs., Mar. 1958; *Rap.* TW 52, 12 pp. + 9 figs., June 1958.

In the first paper (March 1958) author has solved the initial value problem. A constant wind starting at time zero blows in the negative y-direction. A semiinfinite, or infinite, barrier is along the x-axis. Depth and density are uniform. Coriolis force and linear friction are included. The method consists of the reduction to a Hilbert problem for sectionally holomorphic functions. A similar problem has been treated by Crease using Wiener-Hopf techniques.

In the June 1958 paper the analysis is extended to winds of any direction and to a barrier extending from $0 < x < \pi$ and $0 < y < \infty$. This barrier is to model the North Sea, and in particular the point $y = 0$, $x = \pi/2$ is to correspond to the Dutch coast.

W. H. Munk, USA

1631. Polukarov, G. V., A numerical method for determining the velocity components of a tidal stream (in Russian), *Trudi Gos. Okeanogr. In-ta* no. 33/45, 115-126, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6728.

Numerical integration of the equations of the tides leads to determination of the velocity components of the tidal stream. Author starts from the differential equations of motion

$$\frac{\partial u}{\partial t} - 2\omega v = - g \frac{\partial \xi}{\partial x}, \frac{\partial v}{\partial t} + 2\omega u = - g \frac{\partial \xi}{\partial y}$$

and the continuity condition

$$\frac{\partial \xi}{\partial t} = - \frac{\partial}{\partial x}(hu) - \frac{\partial}{\partial y}(hv)$$

where u, v are the components of the velocity of the tidal current along the x and y axes; ξ is the ordinate of the free surface; $2\omega = 2\omega' \sin \varphi$; φ = latitude of the place, ω' = angular velocity of terrestrial rotation; h = depth of the sea. Author restricts consideration to the calculation of the components of the ebb-and-flow currents determined by a single semi-diurnal lunar wave.

Putting u, v, ξ in the form

$$u = u^{(1)} \cos \sigma t + u^{(2)} \sin \sigma t$$

$$v = v^{(1)} \cos \sigma t + v^{(2)} \sin \sigma t$$

$$\xi = \xi^{(1)} \cos \sigma t + \xi^{(2)} \sin \sigma t$$

and applying the method of finite differences, author finds $u^{(1)}$, $v^{(1)}$, $\xi^{(1)}$, $u^{(2)}$, $v^{(2)}$, $\xi^{(2)}$. The boundary conditions are determined from observed data. The resulting system of algebraic equations is solved by the iteration method. A detailed scheme of calculation and a diagram of the calculated velocity field of the tidal stream are appended. It is noted that the deviation of the calculated data from the observed values averages not more than 20%.

A. S. Sarkisyan

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1632. Bartels, J., Tide-generating forces (in German), Encyclopedia of Physics, **48**, Geophysics 2, Springer-Verlag, 734–774, 1957.

This is a monograph on the study of tide-generating forces written by a well-known specialist. The contents are: (A) Elementary discussion, 1. Introduction, 2. Computation of the tide-generating forces, 3. Lunar tide-generating potential, 4. Solar tide-generating potential, 5. Equilibrium theory of tides, 6. Ratio of solar and lunar tide-generating forces, 7. Mutual attraction, 8. Daily change of the tide-generating potential at a fixed point, 9. Geographical distribution of the tide-generating force, 10. Further discussions. (B) Harmonic analysis, 11. Horn's harmonic expansion of tide-generating potential, 12. Orbital motion of sun and moon, 13. Doodson's harmonic development of the tide-generating potential, 14 and 15. Most important terms of Doodson's harmonic development, 16. Diurnal tides, 17. Semi-diurnal tides, 18. Miscellaneous, 19. Graphical illustrations, 20. Harmonic development of the tide-generating forces, 21. Practical computation, 22. Darwin's harmonic development, 23. Season-number.

It is a nice review, with 17 figures and 16 references.

H. Arakawa, Japan

1633. Ruzin, M. I., Some problems in kinematics of atmospheric flows (in Russian), *Vestnik Leningr. In-ta* no. 5, 119–140, 1954; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5777.

A method is proposed for calculating the pathway of an air particle in a free atmosphere, taking into account the acceleration and declination of the wind owing to geostrophic effect. The terms of the problem bring together the finding of the trajectory of the particle as a function from initial coordinates and time, for which purpose solutions are carried out together of a system of equations for the motion of an ideal liquid and the equation of continuity (following Lagrange). In order to simplify the formulas, an evaluation is made of the order of magnitude of the members and the derivatives entering into them, approximated in the form of end differences and determined by charts AT_{900} and AT_{700}. The problem is solved by the method of successive approximations. On the basis of the relations obtained, trajectories of the particles are constructed at the level of the 750 mb surface. It appears that the actual trajectories uninterruptedly diverge from the simplified ones (average 165 km in 24 hours), and this divergence is caused mainly by the nonstationary condition of the field of pressure. Divergences are most probable at low wind velocities, the values of which are close to values of the declination of the wind due to geostrophic effect, and in consequence are observable more frequently at centers of barographic systems and are practically not to be found on the rectilinear cuttings of the structure contour. The calculated means for 12 hours of vertical velocity at a height of 3 and 1 km are compared with the dynamic change of pressure at earth level, the vergi in the planetary layer of friction, with the cloudiness and the vertical temperature gradient. It is explained that when the values of the actual changes in pressure coincide with the values of dynamic changes good agreement is observed between the course of the zero isobar and the zero isoline of the vertical velocity. Notwithstanding the fact that the author made use of the materials derived from the investigations of arid winds of 1949–1950 and that conditions for cloud formation were unfavourable (low relative humidity), it can be recorded that there was satisfactory coincidence of regions with cumulus cloudiness and regions with positive values for vertical velocity.

E. A. Burman

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

1634. Sterne, T. E., High-altitude atmospheric density, *Physics of Fluids* **1**, 3, 165–170, May–June 1958.

Author's summary states "Atmospheric density values obtained from the motion of artificial earth satellites, at altitudes between 186 and 656 kilometers, are discussed. There is some doubt about the reliability of densities from satellites because of the effects of ionization and, in the case of nonspherical satellites, because of their orientation. Densities inferred from satellites are higher than for the ARDC model of the atmosphere. These densities are about ten times higher than densities inferred from rocket-borne ionization gages between 186 and 230 kilometers.

"The inference of atmospheric density from rocket-borne ionization gages is discussed critically, and densities so obtained are considered to be inferior in reliability to the satellite densities. The satellite densities suggest molecular scale temperatures higher than those of the ARDC model in one or more regions of altitude above 80 kilometers."

The reviewer recommends this article for its physical and mathematical analysis. A. S. Andes, USA

1635. Magata, M., On the truncation errors in numerical prediction, *Pap. Meteor. Geophys.* **8**, 2, 133–143, July 1957.

In numerical weather prediction, nonlinear partial differential equation is used in a finite difference form and behavior of truncation error gives rise to discussion. In order to study it, author compares solution of equation of finite difference form with analytically exact solution of original equation; he concludes that so far as large-scale perturbation is concerned, truncation error is unimportant, but in case of small-scale perturbation it cannot be ignored. Especially in forecasting path of relatively small-scale cyclone such as typhoon by ordinary numerical prediction method, speed of cyclone is known to be smaller than observed value, but this fact can also be explained by behavior of truncation error.

H. Arakawa, Japan

Naval Architecture and Marine Engineering

(See also Revs. 1140, 1208, 1437, 1463)

Book—1636. Sherman, F. S., editor, Symposium—Naval hydrodynamics, Washington, D. C., National Academy of Sciences-National Research Council Publication 515, 1957, xiv + 444 pp.

This book includes the papers and discussions presented at the Symposium on Naval Hydrodynamics held in September, 1956. The material includes surveys and original contributions in most fields of hydrodynamics which are of interest to the naval scientist, engineer and architect. The contributors are outstanding authorities, and with the associated discussions have prepared treatments of the subjects which present the state of the science at the time the papers were given.

A very brief summary of the papers follows:

L. M. Milne-Thomson discusses some current problems and methods in hydrodynamics, including applications of quarternion functions to flow problems, problems of virtual mass, free-streamline theory and submarine motion.

M. J. Lighthill, "River waves," presents his simplified theory of river waves. Discussion is by Stoker and Morikawa.

W. H. Munk, M. J. Tucker, F. E. Snodgrass, "Remarks on ocean wave spectrum," present a discussion of the status of ocean wave analysis based on spectral energy methods. They point out the difficulties of obtaining satisfactory detailed information on the two-dimensional spectrum. Discussion is by Longuet-Higgins and W. Pierson.

Georg P. Weinblum, "Contribution of ship theory to the seaworthiness problem," presents a very comprehensive review of the entire subject of seaworthiness, including the effect of seaway and ship form on the motions and responses of ships. Discussion is by P. Kaplan, E. V. Lewis, Szebehely, Golovato, Gawn, Allan and Korvin-Kroukovsky.

John J. Wehausen, "Wave resistance of thin ships," presents, using formal perturbation techniques, a thorough discussion of the linearized Mitchell problem and indicates extensions to the various possible nonlinear formulations. Mitchell's integral is obtained and the limitations of the theory are explained. Comparisons between theory and experiments are given and finally the problem of ship forms for minimum wave resistance is discussed and the author calls attention to the basic need for existence theorems in this connection. Discussion is by Benjamin, Stoker, Chisnell and Eames.

J. C. Niedermair, "Hydrodynamic barriers in ship design," discusses problems encountered by the naval architect in actual design work and points out the areas in which additional information is needed if the design is to be improved or the designers task is to be simplified. Discussion is by Gawn, Saunders, Allan, Davidson, Todd, deLuce, Eames and Moberg.

H. W. Lerbs, "On the development of the theory of marine propulsion," discusses the status of analytical work in the field of marine propulsion, including propeller-body interaction. Discussions by Tachmindji, Martinek and Yeh, R. Hunziker, Silverleaf, Wu, Hoerner, Florio, Eisenhuth and Gawn.

John B. Parkinson, "Hydrodynamics of high-speed water-based aircraft" reviews briefly the basic considerations involved in the design of water-based aircraft as influenced by the requirements for high-speed flight. Comments are by Schoech, Fenn, Hopkins, Gawn, J. D. Pierson, Savitsky and Eames.

R. N. Cox and J. W. Maccoll, "Recent contributions to basic hydroballistics," discuss fundamental research concerned with the motions of projectiles through liquid mediums, including water entry. Topics include discussions of shock phase, water entry phase and the cavity phase. Birkhoff, Burt, Nicolaides, Fabula and Berger describe recent work being done by themselves and their associates in this field.

H. M. Fitzpatrick and M. Strasberg "Hydrodynamic sources of sound." Paper describes theoretical and experimental work dealing with underwater sound phenomena. The sounds considered are those due to entrained air bubbles, cavitation, surface disturbances and unsteady flow. Relations are given between various flow parameters and the intensity and spectral distribution of sound. Discussers included Byard, Batchelor, Lighthill, Congwer, Benjamin and Gilmore.

David Gilbarg, "Free-streamline theory and steady-state cavitation," discusses theoretical aspects of various free-streamline theories, including those of Helmholtz-Kirchhoff, Riabouchinsky, Garabedian, Lavrentieff, and Gilbarg and Serrin. Discussion is by C. J. Cohen, Gates, Wu, Tulin and Imai.

M. S. Plesset, "Physical effects in cavitation and boiling," presents a theoretical solution (and experimental confirmation) for the growth of a vapor bubble in a superheated liquid. Surface tension, liquid inertia, heat transfer and pressure differential effects are considered. Discussers include Gawn, Herzfeld, Gilmore, Preiser, Eisenberg, and Batchelor.

Hans G. Snay, "Hydrodynamics of underwater explosions," analyzes the shock-wave formation by an underwater blast with associated shock-wave propogation and surface reflection effects; bubble behavior; surface effects, including the spray dome, breakthroughs, venting, and plume formation; and the response of simplified structures to underwater blasts. Discussions are by Chertock, Reed, and Hudson.

C. C. Lin, "On the stability of the laminar boundary layer," presents a survey of boundary-layer stability and transition theories and experiments and also outlines an improved mathematical theory for uniformly valid asymptotic solutions of the Orr-Sommerfeld equation. Discussions are by Wasow, Benjamin, and Klebanoff.

S. Corssin, "Some current problems in turbulent shear flows," discusses in terms of shear stress, strain-rate and their fluctuations the shear flows of boundary layers, channels, wakes and jets. Comments are by Wieghardt, Landweber, Hama, Stewart, Silberman, Batchelor, and Tulin.

G. K. Batchelor, "Wave scattering due to turbulence," presents a theoretical treatment for the case in which a sound wave strikes a nonuniform medium, the nonuniformity being in, say, velocity or in some other physical property which is, in turn, due to the presence of turbulence. Discussions are by Mintzer, Kraichnan, and Lighthill.

S. F. Borg, USA

1637. Kostilainen, V., Hydrofoil craft and their stability, *European Shipbldg.* **7**, 2, 36–42, 1958.

Problem treated is that of the transverse stability of hydrofoil craft fitted with surface-piercing hydrofoils (area-stabilized). Treatment is limited to the single hydrofoil operating in calm water and the effect of supporting structure is disregarded. Solution is given for two cases: (a) Even distribution of lift, where the hydrofoil tips remain emergent and (b) uneven distribution of lift, which includes, as a special case, the condition of submerged tips. In the former case, a solution is worked out for a Vee-hydrofoil; in the latter, a graphical method is expounded.

M. St. Denis, USA

1638. Basin, A. M., Rolling of ships with low freeboard (in Russian), *Trudf Leningr. In-ta Inzh. Vod. Transp.* no. 23, 212–218, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5599.

The rolling of a ship in a stormy sea is studied in apparatus devised by A. N. Krylov; the hydrodynamic forces are assumed to be known functions of the angle of heeling and its derivative. The problem leads to the nonlinear equation

$$\frac{d^2\varphi}{d\tau^2} + \frac{\mu}{\omega} f_c \left(\omega, \frac{d\varphi}{d\tau}\right) + f_\theta(\varphi) = a_\theta \sigma^2 \sin \sigma\tau \qquad [1]$$

where φ is the angle of heeling, f_θ and $(\mu/\omega)f_c$ the reestablished and damping moments of the hydrodynamic forces, ω the frequency of the free rolling movements of the ship in the absence of resistance, a_θ the angle of wave inclination, τ undimensional time. The problem is set of finding the possible periodic solutions of the nonlinear Eq. [1] of the period of the disturbing force. Following standard procedure for averaging, the solution is sought in the form

$$\varphi = \varphi_m \sin(\sigma\tau + \psi)$$

In order to determine φ_m and ψ, transcendental equations are deduced. Later, the following simplifying assumptions are introduced

$$(1)\ f_c \left(\omega, \frac{d\varphi}{d\tau}\right) = c_1 \frac{d\varphi}{d\tau} \qquad \text{where } \varphi < \varphi_1$$

$$f_c \left(\omega, \frac{d\varphi}{d\tau}\right) = c_2 \frac{d\varphi}{d\psi} \qquad \text{where } \varphi > \varphi_1$$

where φ_1 is the angle at which the deck enters the water, $c_2 > c_1$ are constants.

(2) The frequency of the disturbing force is equal to the frequency of the free oscillations (the resonance case, giving the maximum value to the amplitude of the compelled oscillations). This leads to the possibility of obtaining in a clear form "the degree of diminuation of the resonance amplitude" through the appearance of supplementary resistance, in consequence of the deck entering the water. N. N. Moiseev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1639. Sukhomel, G. I., and Zass, V. M., The change in draft of a ship in motion (in Russian), *Rechnoy Transport* no. 11, 16–22, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6743.

Authors summarize the known data on the influence of limited channel depth on the resistance and change in mean draft of a ship moving in shallow water.

From the results of earlier theoretical investigations and experimental researches, an approximate formula is recommended for determining the change in mean draft of a ship gravelling in shallow water.

In the opinion of the authors, the "Rules for the technical operation of the fleet of the USSR," and the "Rules for navigation on inland waterways" require revision in the parts concerning the determination of the necessary reserve of depth to be allowed for craft passing over (river) bars. Ya. I. Voitkunskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1640. Basin, A. M., Rolling and ship stability in waves (in Russian), *Trudl Tsentr. N.-i. In-ta Rech. Flota* no. 30, 3–54, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6733.

The rolling of a ship broadside to the sea is investigated in consideration of the periodic variation of the magnitude of the buoyancy force. It is assumed that the ship is short compared with the wave length. Owing to the fluctuations of the surface of the water and vertical scending, there is a periodic variation in the buoyancy force. This leads to a parametric resonance in the rolling motion of the ship. The conditions for the excitation of such parametric resonance are investigated for the cases of a linear and nonlinear static stability diagram of the ship, and expressions are set up for determining the minimum value of the angle of the wave slope required for parametric excitation of oscillation for a given coefficient of resistance; curves are plotted for the relationship between amplitude and frequency for the principal parametric resonance region. The constrained oscillations of the ship are analyzed for the presence of a nonlinear restoring (righting) moment and scending; the steadiness of different conditions of constrained oscillation is investigated; and conclusions are made concerning the quantitative effect of scending on the rolling of a ship, which is considered to be slight.

S. N. Blagoveshchenskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1641. Guliyev, Yu. M., and Pavlenko, V. G., The experimental investigation of the rolling of ship models by the method of forced oscillation (in Russian), *Trudl Vladivostoksk. Vyssh. Morekhod. Uch-shche* no. 1, 84–91, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6735.

A description is given of a rocking device consisting of two weights rotating about axes located in the diametral plane of the model. A nonlinear differential equation is written for the motion of the model under the influence of the rocking apparatus. Instead of a rigorous solution of this equation, author applies the known approximate method of harmonic approximation. The constrained oscillations are sought in the form

$$\theta = \theta_0 \sin \sigma t.$$

The differential equation is satisfied in the equilibrium position and at the points of maximum deflection. Approximate expressions are then obtained for determining the relationship of the moment of resisting forces to the angular velocity, for the phase angle and the equivalent angle of the wave slope. The work is an application of known methods to the concrete case of the rolling of a (ship) model. A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1642. Jacobs, Winnifred R., The analytical calculation of ship bending moments in regular waves, *J. Ship Res.* **2**, 1, 20–29, June 1958.

The longitudinal distribution of hydrodynamic forces acting on a T2-SE-A1 tanker moving in regular head seas is found by use of the "strip method" developed by Korvin-Kroukovsky in his studies of ship motions. Midship bending moments are calculated, compared with those measured in model tests, and found to be of the same order of magnitude. Both this study and the experiments indicate that load distribution affects the bending moment more than the wave action and that the dynamic bending moments are less than those predicted by conventional naval architectural methods using the Smith correction. F. E. Reed, USA

1643. Irkhin, A. P., and Stepanov, E. I., Determination of the safe depth of water under the bottom of a self-propelled cargo ship (in Russian), *Trudl Tsentr. N.-i. In-ta Rech. Flota* no. 30, 100–128, 1955; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6741.

Authors point out that the draft and trim of a ship in motion may differ considerably from the same values measured when the ship is at rest. This is a circumstance of particular importance at the present day, when new high-speed and heavy-draught ships are being brought into service; neglect of this may lead to accidents (examples are given).

The work contains a detailed description of the model tests of two different ships (model scale 1:25). In addition to the trim and draft, the resistance forces were measured. Further, a comparison is made between model and full-scale tests. The work contains a mass of numerical data and graphical material, as a result of the evaluation of which the standardization of safe depths in relation to draft and speed figures (full and slow speeds) is proposed.

N. N. Moiseev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1644. Suhara, J., On the strength of fore poppet at launching, *Mem. Fac. Engng., Kyushu Univ.* **17**, 3, 129–138, Mar. 1958.

A consideration of the loads and length of load-carrying contact for the forward launching poppet of ship. The poppet is fitted with soft wood crushing strips. F. E. Reed, USA

1645. Clarkson, J., On the transverse strength of ships, *European Shipbldg.* **7**, 2, 43–51, 59, 1958.

Purpose of article is to describe research performed at the Naval Construction Research Establishment on the mechanics of ships' structures under statically applied loading. The article concerns itself mainly with explaining the extension of advanced structural theory to the design and stress analysis of ships. Such items as behavior of flat plates under lateral pressure, and flat and cylindrical grillages are included. C. B. Matthews, USA

1646. Shimanskii, Yu. A., Investigation of the most important factors influencing the work of ships' propeller shafts (in Russian), Sb. Statei po Sudostroeniyu, Leningrad, Sudpromgiz, 1954, 248–319; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 6081.

A study is made of the influence on the work of a flexible ship propeller shaft of the general and local deflections of the ship's hull, of the clearances in the flanged connections, of the axis being off-center, improper handling and so forth. It was shown how unfounded were the earlier existing stringent standard tolerances in setting up these shafts and, linked with this, the bases of the rationalization of the technological process of assembly are indicated. One of the author's deductions, obtained from the investigation of the elastic line of the shaft, is to the effect that the general deflection of the ship's hull in the water cannot adversely influence the work of the shaft, and in consequence the installation of the assembly can be effected before the vessel is launched. F. M. Dimentberg

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

1647. Bogdanova, Z. V., and Pichuzhkin, V. P., Experimental investigation of the distribution of pressure on the surface of a moving ship (in Russian), *Trudi Tsentr. N.-i. In-ta Rech. Flota* no. 30, 129-184, 1955; *Ref. Zh. Mekh.* no. 5, 1957, Rev. 5609.

Results are given of the experimental investigations of the distribution of the pressure of water on the wetted surface of the model of an unpowered vessel being towed in a rectangular channel of trapizoidal form in the small experimental basin of the Ts NIIRF. The pressure was measured at a series of points on the surface by means of specially contrived fluid transmitters of resistance with electrical recordings on an oscillograph. In addition, measurements were made of the riding of the model when in motion relative to the surface of the smooth water, of the change of the outline of the wave on the side of the model relative to the load water line and of the change of the outline of the free surface of the water at different distances from the model. A series of deductions was made regarding the influence of the limits of the waterway on the different components of resistance (of the shape of the wave and friction) and of the parts played by the separate portions of the hull due to the creation of resistance of the water to the ship's movement in a limited waterway. Steps are indicated to reduce the resistance. S. N. Blagoveshchenskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Friction, Lubrication and Wear

(See Rev. 1164)

Letter to the Editor

1648. Re: AMR **11**, Review 4979 (December 1958): Biot, M. A., Dynamics of viscoelastic anisotropic media, Proc. Second Midwestern Conf. Solid Mech., Purdue Univ., Sept. 1955, 94-108.

Author's name appeared as Blot instead of Biot. The editors regret this error.

Books Received for Review

AAS-JAKOBSEN, A., Die Berechnung der Zylinderschalen, Berlin, Springer-Verlag, 1958, xii + 160 pp. DM 22.50.

DUKE, C. M., Bibliography of effects of soil conditions on earthquake damage, San Francisco, Calif., Earthquake Engineering Research Institute, 1958, iii + 47 pp. $1.00 (paperbound).

FORDER, H. G., The foundations of Euclidean geometry (unabridged republication of 1927 edition), New York, Dover Publications, 1958, xii + 349 pp. $2.00 (paperbound).

FRODA, A., Algebra Superiorara fundamente: multimi si operatii divizibilitate spatii liniare forme patratice (Biblioteca Matematica I), Bucarest, Rumania, Editura Academiei Republicii Populare Romine, 1958, 454 pp. Lei 24.50.

GRUBENMANN, M., I-x Diagramme feuchter Luft und ihr Gebrauch bei der Erwarmung Abkuhlung, Befeuchtung, Entfeuchtung von Luft bei Wasserruckkuhlung und beim Troknen, Berlin, Springer-Verlag, fourth enlarge edition, 1958, vi + 41 pp. + 4 diagrams. DM 15.60.

HANCOCK, H., Elliptic integrals (unabridged republication of 1917 edition), New York, Dover Publications, 1958, 104 pp. $1.25 (paperbound).

HANCOCK, H., Lectures on the theory of elliptic functions (unabridged republication of 1909 edition), New York, Dover Publications, 1958, xxiii + 498 pp. $2.55 (paperbound).

MACMILLAN, W. D., Statics and the dynamics of a particle (unabridged second edition), New York, Dover Publications, 1958, xviii + 430 pp. $2.00 (paperbound).

MACMILLAN, W. D., Theoretical mechanics: The theory of the potential (unabridged republication of 1930 edition), New York, Dover Publications, 1958, xiii + 469 pp. $2.25 (paperbound).

NESTORIDES, E. J., edited by, A handbook on torsional vibration (BICERA), New York, Cambridge University Press, 1958, xxii + 664 pp. $19.50.

PARKE, N. G., III, Guide to the literature of mathematics and physics including related works on engineering science (revised and expanded version of 1947 edition), New York, Dover Publications, 1958, xviii + 436 pp. $2.49 (paperbound).

PERRY, J. W., and KENT, A., Tools for machine literature searching (Library Science and Documentation, Vol. I), New York, Interscience Publishers, 1958, xvii + 972 pp. $27.50.

PRIGOGINE, I., edited by, Advances in chemical physics, Vol. I, New York, Interscience Publishers, 1958, xi + 414 pp. $11.50.

PRIGOGINE, I., edited by, Proceedings of the International Symposium on Transport Processes in Statistical Mechanics, Brussels, August 27-31, 1956, New York, Interscience Publishers, 1958, x + 436 pp. $10.00.

RUSU, G., Tehnica Masuratorilor in Constructiile Masiv (Monografii de Tehnica VI), Bucarest, Rumania, Editura Academiei Republicii Populare Romine, 1958, 317 pp. Lei 25.90.

SOMMERVILLE, D. M. Y., An introduction to the geometry of N dimensions (unabridged republication of 1929 edition), New York, Dover Publications, 1958, xvii + 196 pp. $1.50 (paperbound).

SOMMERVILLE, D. M. Y., The elements of non-Euclidean geometry (unabridged republication of 1914 edition), New York, Dover Publications, 1958, xvi + 274 pp. $1.50 (paperbound).

How to Obtain Copies of Articles Indexed

Photocopy or microfilm copies of articles reviewed in this issue will be provided whenever possible. Orders should specify the APPLIED MECHANICS REVIEWS volume and review number.

Except as indicated below, address orders to LINDA HALL LIBRARY, 5109 Cherry Street, Kansas City 10, Mo., and include remittance to cover costs. Orders to Linda Hall Library may also be placed by teletype, using the number KC334. Complete copies of the articles reviewed in Referativnyi Zhurnal and reprinted in AMR are received by the editors of AMR or by Linda Hall Library a considerable length of time after publication of the review, and therefore are not immediately available. Photocopy costs are 35¢ for each page of the article photocopied, minimum charge $1.25; microfilm costs include a service charge of 50¢ per article plus 3¢ per double page, minimum charge $1.25. *The applicant assumes responsibility for questions of copyright arising from copying and the use made of copies. Copyright material will not be reproduced beyond recognized "fair use" without consent of the copyright owner.*

To secure copies of reviewed papers from English-translated issues of Russian journals, apply to the English language publisher given in the review heading. Photocopying of such translations is often expressly forbidden. Costs will vary with the publisher.

TRANSACTIONS

OF THE ASME

Now published in these 5 Quarterlies

Series A – JOURNAL OF ENGINEERING FOR POWER will present significant papers on the following subjects: Power generation and usage; conversion of energy sources to power generation; design, operation, and application of all types of gas turbine prime movers; preparation and use of fuels; fuel burning equipment design and operation; control and utilization of the products of burning processes; application of nuclear energy; reactor design components and techniques; reactor safeguards; waste disposal and radiation hazards; internal combustion engines and their auxiliaries – their design, construction, application, and operation; air pollution problems; solar energy application. Published in January, April, July, and October.

Series B – JOURNAL OF ENGINEERING FOR INDUSTRY will report major advances, and provide original information on certain aspects of aircraft and missile design; machine design; mechanical engineering phases of process industries, with emphasis on unit operations; maintenance and plant engineering; management procedures and skills; human engineering factors; materials handling equipment and techniques; machining and assembly of metal parts, with their related problems; manufacture and use of rubber and plastics relating to mechanical engineering; special areas of the petroleum field; safety; textile machinery and procedures; wood utilization, wood working machinery and operation, and bonding of woods.
Published in February, May, August, and November.

Series C – JOURNAL OF HEAT TRANSFER will cover the activities of the field and particularly important problems associated with radiation, conduction, convection, complex systems, phase changes and mixtures, transient phenomena, thermophysical properties, experimental techniques, thermometry, analog methods, analytical and numerical methods, applications, design techniques, heat exchangers, insulation, economic factors, biotechnology, astronautics.
Published in February, May, August, and November.

Series D – JOURNAL OF BASIC ENGINEERING focuses attention on developments in the following areas of the mechanical engineering field: Lubrication; mechanics of fluid motion; hydraulic machinery, fundamental researches in hydrodynamics; instruments and automatic controls; new metals, metal-forming processes, and testing procedures, and better engineering application of metals. Research reports on automatic regulation theory, effective temperature on the properties of metals, mechanical pressure elements, fluid meters, prevention of fracture in metals, plastic flow of metals will also be published in this Quarterly.
Published in March, June, September, and December.

Series E – JOURNAL OF APPLIED MECHANICS. This magazine has been in existence for twenty-four years. As in the past, it will report fundamental analytical and experimental studies in the fields of elasticity, plasticity, dynamics, vibration, impact, flow and fracture, structures, stress analysis, mechanical properties of materials, hydraulics, aerodynamics, internal flow, turbulence, boundary layers, aeroelasticity, thermodynamics, heat transfer, lubrication and wear, and computing devices and methods. Where subjects overlap the fields covered by the other publications of this Series, the Journal of Applied Mechanics will deal with the basic laws and the more advanced methods of studying problems.
Published in March, June, September, and December.

ANNUAL SUBSCRIPTION PRICES to nonmembers: \$10 for each Journal, \$18 for any two Journals, \$25 for any three Journals, \$30 for any four Journals, \$33 for all five Journals.

PRICES TO ASME MEMBERS ARE 50% LESS

Add 50¢ to price of each Journal if mailed outside of U.S., Canada, and Pan-American Union countries.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 W. 39th St. **New York 18, N. Y.**

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE *(Continued)*

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

(Continued on outside back cover)

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE *(Continued)*

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)